FACULTY OF PSYCHOLOGY
AND EDUCATIONAL SCIENCES

Basic psychological needs and sleep: A multi-method inquiry into their relation and underlying mechanisms in non-clinical and clinical samples

Rachel Campbell

Supervisor: Prof. Dr. Maarten Vansteenkiste
Co-supervisor: Prof. Dr. Dirk Vogelaers

A dissertation submitted to Ghent University in partial fulfilment of the requirements for the degree of Doctor of Psychology

Academic year 2016–2017

GHENT
UNIVERSITY

ACKNOWLEDGEMENT

Just a little over four years ago I took a train to Ghent, a place I had never been before, to interview for this PhD project. To my big surprise later that day I received an e-mail offering me the position and with that I was moving to Ghent! Moving to a new country and completing a PhD were not always easy, but I can honestly say now that I am very happy that I did both. Over the past few years I learned an incredible amount and I’ve grown a lot not only as a researcher but also as a person. I feel extremely lucky to have found a job which allows me to write and read about topics that I find fascinating on a daily basis. There are a number of people who supported me throughout the past four years who I would like to thank.

Maarten, without you I would never have been given the opportunity to do this PhD in the first place, so thank you for taking a risk on an Irish girl and inviting me to join the group. To say I was overwhelmed by you in the beginning would be an understatement. From the get go you were fast talking and absolutely full of energy. In several of our meetings I often wished I’d brought a tape recorder with me just to try and fully capture the volume of ideas that you had come up with, sometimes even multiple within one breath of air. This dissertation is the direct product of the many discussions that we shared. Thank you for your support and guidance throughout this whole process and for challenging me to think critically and deeply about each and every study. Despite your busy schedule you were always available to talk things through, provide help and to listen to any frustrations. Your enthusiasm for research is truly infectious, and the effort you put into translating research findings into practice is inspiring to be around. I have really enjoyed working with you and hope that we will be able to continue to do so in the future. Also, thanks for teaching me a number of valuable Flemish phrases. In the future whenever I’m struggling I’ll make sure to remember “Het is nog al niet naar de wuppe … doe maar voort”!

Bart, I would like to sincerely thank you for your interest in my work and for your input in many of the chapters within this dissertation. I really appreciated that whenever I knocked on your door

you were always willing to discuss ideas and provide help. I've really enjoyed getting to know you and working with you the past few years. Lisa and Beatrijs, you are both the best office buddies anyone could wish for. The many laughs and chats we had about every topic under the sun provided a lot of necessary breaks from our serious day jobs. Thank you both for always being there to provide practical help and for being my living Dutch dictionaries. Lisa, thank you for being my sounding board and helping me to sort through my thoughts and ideas both work related and otherwise. Beatrijs, thank you for bringing so much brightness and positive energy into the office, you were always there to share both happy moments and frustrations. Jochen, I don't know where I would've been without your motivational high fives! You are such a friendly, thoughtful colleague, with a real talent for coming up with creative topics to discuss at lunch time. Gert-Jan, thank you for being always being so friendly and positive, I really enjoyed the many chats, lunches and sports activities that we shared. Jolene, you were always there to lend a helping hand with any questions I had throughout the years which I really appreciated. Sara, even though you weren't officially a member of our group I always felt like you were. I have really good memories of the conferences we went to together in Rochester, Innsbruck and Victoria. Joachim the newest (unofficial) addition to the group, it has been so nice to see someone coming in so full of enthusiasm. Thanks for helping to make our work environment more fun. To all the other members of the group, thank you for all the interesting seminars we had and for sharing your findings. Katrien and Steven, thank you both for all the practical help and support over the years. Kaya, although you left a number of years ago I want to thank you for being so welcoming when I arrived and helping me to settle into Ghent. I still miss our walks home and discussions about all sorts of life dilemmas. Thanasis, another far away colleague, thank you for all of your statistical support and patience.

I would also like to thank my colleagues at the clinic for opening their doors to us and allowing us to do research with them. Els and Liesbet I really appreciated your help collecting data in the clinic as well as your interest and contributions to the studies. I haven't been in the clinic as much lately but I enjoyed sharing an office with you both in the past. An and Dirk thank you both for allowing us to do

research with the patients and for providing us with access to the sleep laboratory. The clinical data you enabled us to collect have been a rich addition to this PhD. Thank you to the many patients and also non-patients who participated in our studies, without which this dissertation would not exist. I still can't believe there are people out there willing to deprive their sleep for the sake of research! Thank you also to Julie Van der Jeucht, Nina Verstraete, Mieke Mussche, Valerie Kindt and Elien Audenaert for helping to collect data.

Mum and Dad just thinking of the million and one things I'd like to say to thank you both makes me feel emotional. A couple of sentences in an acknowledgment are not enough to do justice to the ocean of things (both big and little) that you have done to support me, not only throughout the last four years, but my whole life. I am forever grateful for the unconditional love, support and encouragement that you have showered me in, even if it meant me physically moving farther away from you in the process. Mum, you have a knack for often knowing me better than I know myself. Without you suggesting that I should look into studying Psychology I may have never discovered the field that I am now so passionate about. Your library of psychology books and magazines are such a treasure trove and inspiration to me, as is the counselling work that you do. Your clients are incredibly lucky to have someone like you there to support them. Dad, you have always been there to offer me advice when needed, to help me put things into perspective and most importantly to laugh at myself. I feel incredibly lucky for the life that you have given us. Kyra, you've been such a help in navigating my way through the whole PhD process. I am in total awe of how you manage to achieve so much in your work and be such a dedicated mother at the same time. Without the daily Whatsapp pictures of my two favourite little people I would have been a lot worse off. Nora and Ali, being your aunty has been the best gift anybody has ever given me. You guys are my instant happiness pill and I love you both to the moon and back. Peter, your constant drive for sporting pursuits always stimulated me to keep fit and push my boundaries. Thanks for all the relaxing and fun trips we had. Maire, the pocket rocket and third unofficial sibbie, you have been an essential component of my relaxation during the past four years. Thanks for all the fun holidays, Skypes and the many couch sessions solving all of the worlds' biggest problems. To all of my friends both near and far, thank you for being there throughout the past four years. In particular, Priya, Ciara, Shellie, Shereena, Niki, Rebeca, Suzanne, Amanda and Ilona, thanks for coming to visit me in Ghent and for being there on Skype or Whatsapp to chat and laugh about nonsense. To the friends I made here in Ghent, Marie-leen, Patricia, Anwesha, Sule, Surya, Ozden, Setareh, & Andrea, thanks for making Ghent such a fun place to be.

Last but not least, I'd like to thank the person who has been farthest away yet closest to me. Brett, despite the 9,248 miles between us (according to Google), you have been my biggest supporter throughout the past two years. My mum and dad will testify to the fact that since we met the half crazed panic-stricken phone calls to them have reduced substantially. Thank you for stepping in to be my support system. You have been there for me every step of the way even if it meant, which it often did, waking up at some ungodly hour to speak to me. You have helped me to believe in myself and get to the end of this PhD happy and determined. Thankfully, the end of this PhD also marks the end of our long distance saga and I couldn't be more excited to discover what the future has in store for us.

Rachel Campbell, June 2017

TABLE OF CONTENTS

Basic Psychological Needs and Sleep: A Multi-Method Inquiry into their Relation and Underlying Mechanisms in Non-Clinical and Clinical Samples

A General Introduction

Table of Contents

Introduction

Most, if not all of us, are likely familiar with the consequences of poor sleep. After a night of tossing and turning in bed it is common to feel fatigued (Fuligni & Hardway, 2006), irritable (Baum et al., 2014) and to have difficulties staying focused on the tasks at hand the following day (Poh, Chong, & Chee, 2016). If sleepless nights persist and become chronic, both physical and psychological health is put at considerable risk. Indeed, long term sleep disturbances are associated with obesity (Aziz et al., 2017), coronary heart disease (Meisinger, Heier, Löwel, Scneider, & Döring, 2007), immune dysfunction (Cohen, Doyle, Alper, Janicki-Deverts, & Turner, 2009), and even greater risk of mortality (Liu et al., 2017). Apart from physical dysfunction, chronic sleep disturbances are also predictive of depression (Pigeon & Perlis, 2007) and anxiety (Pires, Bezerra, Tulfik, & Andersen, 2016) and have been put forward as a transdiagnostic risk factor for the development of psychopathology (Harvey, Murray, Chandler, & Soehner, 2011). Finally, sleep disturbances also have an enormous societal cost due to reduced work productivity, excess sickness absence, workplace accidents and healthcare costs (Kessler et al., 2011; Wade et al., 2011).

Worryingly, recent estimates indicate that the prevalence of sleep disturbances is high and on the rise (Ford, Cunningham, & Croft, 2015). Average sleep duration has decreased significantly since the 1980s with up to 40% of the general public reporting less than 6 hours of sleep a night on average (Ford et al., 2015; Jones, 2014). This is considerably below public health recommendations which state that adults need at least 7 hours of sleep per night to function optimally (Watson et al., 2015). Sleep disturbances are not limited to adult populations and are also highly prevalent among younger age groups including emerging adults (Lund, Reider, Whiting & Prichard, 2010) and adolescents (Gradisar, Gardner, & Dohnt, 2011). Furthermore, a striking number of individuals endure chronic sleep disturbances with it being estimated that up to 15% of the general public suffer from clinically diagnosed insomnia (Ohayon, 2007). Insomnia typically involves difficulties initiating or maintaining sleep, having nonrestorative or unrefreshing sleep, as well as experiencing considerable fatigue and daytime impairment (American Psychiatric Association, 2013).

Insomnia as a symptom is a highly prevalent health complaint among individuals with a range of psychiatric and medical disorders. For example, although the predominant complaint among individuals with Chronic Fatigue Syndrome (CFS) is enduring fatigue that is not alleviated by rest, nonrestorative sleep is also a key symptom of CFS (Fukuda et al., 1994). Up to 95% of individuals with CFS report unrefreshing sleep (Nisenbaum, Jones, Unger, Reyes, & Reeves, 2003), and several studies indicate that sleep disturbances exacerbate and maintain symptoms of CFS (e.g., Gotts, Newton, Ellis, & Deary, 2015; Russell, Wearden, Fairclough, Emsley, & Kyle, 2016). Another clinical group which suffers from sleep disturbances is people living with HIV (PLHIV). Although health-related quality of life is a central issue among PLHIV (Lin, Wu, & Revicki, 2002), sleep disturbances also constitute a major concern within this patient group. Indeed, it is estimated that up to 58% of PLHIV are affected by sleep difficulties (Wu, Wu, Lu, Gui, & Pengsheng, 2015). Given that sleep disturbances among PLHIV are related to poorer HRQOL (Phillips, Mock, & Bopp, 2006; Phillips, Sowell, Boyd, et al., 2005), and that poor sleep is implicated in immune dysfunction (Cohen et al., 2009; Wilder-Smith, Mustafa, Earnest, Gen, & MacAry, 2013), sleep disruption represents a serious problem within this clinical group.

In light of the widespread prevalence of sleep disturbances and the impact of poor sleep on physical health and psychological well-being, it is imperative that research seeks to identify antecedents of individuals' quality and quantity of sleep. Acknowledging this, a number of previous studies have examined the role of psychological factors in predicting sleep. For example, financial strain (Burgard & Ailshire, 2009), perceived stress (Lund et al., 2010), rumination (Pillai, Steenburg, Ciesla, Roth, & Drake, 2014) and negative pre-sleep cognitions (Wood, Joseph, Lloyd & Atkins, 2009) have been found to relate to poorer sleep outcomes. In addition, several studies have also examined more protective factors and have found that gratitude (Wood, et al., 2009), optimism (Lemola, Räikkönen, Gomez, & Allemand, 2013), and mindfulness (Howell, Digdon, & Buro, 2010; Howell, Digdon, Buro, & Sheptycki, 2008) relate to better sleep outcomes.

However, although a number of existing theoretical models of insomnia, (e.g., the cognitive model, Harvey 2002; the attention-intention-effort pathway, Espie, Broomfield, MacMahon, Macphee, & Taylor, 2006; & the hyperarousal model, Riemann, et al., 2010), delineate how psychological factors may relate to sleep, previous studies examining psychological predictors of sleep have not always been grounded in an overarching theoretical framework. Furthermore, although several models of chronic sleep disturbances posit somatic and cognitive arousal processes as playing a central role in the precipitation and maintenance of sleep difficulties (e.g., Espie, et al., 2006; Harvey, 2002; Riemann, et al., 2010), there have been few attempts to adopt a more integrated approach by examining the interrelationship between psychological predictors and sleep-interfering arousal processes in the prediction of sleep outcomes. In addition, despite increasing evidence that sleep and psychological functioning are likely to be bi-directionally related (e.g., Lau, Hui, Lam, & Cheung, 2017; Tavernier & Willoughby, 2014) many previous studies have neglected to examine possible reciprocal associations between psychological factors and sleep outcomes.

In the present dissertation we sought to fill some of these gaps by adopting a theory-driven approach and examining whether the satisfaction and frustration of the basic psychological needs for autonomy, competence, and relatedness, as conceived within Self-Determination Theory (Ryan & Deci 2017; Deci & Ryan, 2000), relates to the deprivation versus restoration of the physiological need for sleep. In doing so, we aimed to adopt a more comprehensive approach to studying sleep by not only examining the relation between need-based experiences and diverse sleep outcomes, but by also investigating the explanatory role of sleep-interfering arousal processes (i.e., perceived stress and negative sleep-related thoughts) in these relations, as well as garnering evidence for the possible reciprocal and causal relations between need-based experiences and sleep outcomes. Furthermore, we sought to further integrate previous findings in the field by examining whether a previously identified predictor of sleep, namely mindfulness, would relate to sleep outcomes through (i.e., accounted for by) psychological need satisfaction. Finally, in contrast to past research (e.g., Carmichael & Reis, 2005; Howell et al., 2008) which sometimes treated sleep as a non-differentiated category comprised of diverse indicators (i.e., by combining indicators of quality and quantity of sleep as well as daytime indicators into a composite score of sleep), we aimed to adopt a heterogeneous approach to measuring sleep by examining whether psychological factors would relate differentially to diverse sleep outcomes.

The overarching theoretical model which guided the studies described within the present dissertation is displayed in Figure 1 on pg. 31. As the reader will notice, the model consists of various different components which will be introduced throughout the following introductory sections. Specifically, we begin by first introducing the concept of basic psychological needs. Next, we discuss the possible intervening mechanisms which may help to explain the hypothesized need-sleep relation. Third, we introduce mindfulness as a possible antecedent of need-based experiences and subsequent sleep outcomes. Fourth, we consider the potential impact of sleep on psychological functioning, thereby discussing the possible reciprocal and causal relations between both need-based experiences and mindfulness and sleep. In each section we briefly review the most relevant literature and identify the specific gaps which provided the impetus for the present series of studies. Finally, this introductory chapter is closed with an overview of the 5 objectives which were pursued throughout this dissertation and a brief overview of the seven empirical chapters that address these objectives.

1. Self-Determination Theory: Basic Psychological Needs

1.1. Psychological Need Satisfaction

The concept of needs has been a topic of debate and study for many decades in psychology (Ryan & Deci, 2017; Deci & Ryan, 2000). In the first half of the 20th century, under the influence of drive theory (Hull, 1943), attention was paid to the study of *physiological* needs (e.g., food). These physiological needs, also called *drives*, function according to homeostatic principles with their deprivation instigating the search for need-fulfilling behaviors to overcome their deficiency. For example, when people are tired they go to bed to replenish their physical resources. Ideally, they then wake up naturally when their physical need for rest is restored. Maslow's hierarchically organized needs-model (Maslow, 1943) also posited physiological needs (i.e., for food, water, warmth, and rest) as first level needs which need to be fulfilled before other higher level needs can be satisfied.

Independent of this body of work, several scholars like Murray (1938), Atkinson (1958), McLelland (1985), and Deci and Ryan (1985) focused on the study of individuals' *psychological* needs. Although a number of psychological theories have adopted a psychological need-based approach, the type, number and conceptualization of the needs posited within each framework varies greatly. Within the present dissertation we focus on psychological needs as conceptualized within Self-Determination Theory (SDT; Deci & Ryan, 2000; Ryan & Deci, 2017), a broad empirically-based theory of human behavior and personality development. Within SDT basic psychological needs are defined as "innate psychological nutriments that are essential for ongoing psychological growth, integrity, and well-being" (Deci & Ryan, 2000, p. 229). SDT specifies three basic psychological needs: the need for *autonomy* which refers to experiencing a sense of volition and self-endorsement in one's activities, the need for *competence* which refers to feeling capable of being able to achieve desired outcomes, and the need for *relatedness* which refers to experiencing a sense of reciprocal care and closeness with important others. When these needs are satisfied people experience a sense of choice and ownership in their behavior and activities (autonomy satisfaction), feel capable of handling daily tasks and challenges (competence satisfaction), and feel close and connected to significant others (relatedness satisfaction).

Psychological needs as defined within SDT share a number of features with physiological needs, including their *inherent*, *essential*, and *universal* character. That is, both types of needs are said to be present in all individuals from birth and their frustration (i.e., when psychological in nature) or deprivation (i.e., when physiological in nature) is said to result in ill-being and impoverished functioning among all individuals regardless of their age, gender, or cultural background. However, one important difference between SDT's psychological needs and physiological needs is that the needs for autonomy, competence, and relatedness are claimed to be growth needs. This means that their satisfaction is said to promote ongoing thriving and optimal functioning. In contrast, physiological needs are deficit needs meaning that they only become operative under conditions of deprivation and that while their satisfaction may lay the groundwork for experiencing well-being, their fulfillment does not necessarily promote enhanced wellness or flourishing. Thus, while the frustration of SDT's psychological needs (i.e., growth needs) and the deprivation of physiological needs (i.e., deficit needs) is said to elicit maladjustment, both types of needs are different in that basic psychological needs don't function according to homeostatic principles, such that their satisfaction leads to a satiation point. In other words, greater psychological need satisfaction is said to yield greater well-being in a linear fashion.

Numerous empirical studies have provided support for the essential and universal character of SDT's needs by demonstrating that their satisfaction is associated with a multitude of positive outcomes among diverse groups of individuals. For example, when these psychological needs are satisfied people report higher vitality, positive affect and self-esteem as well as feeling more satisfied with their lives in general (Deci & Ryan, 2000; Ryan & Deci, 2017). Similar findings have emerged across diverse life domains (e.g., work, education, sport & healthcare e.g., Van den Broeck, Vansteenkiste, De Witte, Lens & Soenens, 2010) and across distinct cultures (e.g., Ahmad, Vansteenkiste, & Soenens, 2013; Chen et al., 2015), as well as both at the between-person and within-person level of analysis (e.g., Reis, Sheldon, Gable, Roscoe, & Ryan., 2000; Ryan, Bernstein, & Brown, 2010). Furthermore, recent evidence suggests that psychological need satisfaction even relates to higher well-being among individuals who report low desire or valuation of these needs (Chen et al., 2015).

1.2. Psychological Need Frustration

Recent theoretical developments within SDT (Vansteenkiste & Ryan, 2013) and empirical studies (e.g., Bartholomew, Ntoumanis, & Thøgersen-Ntoumani, 2011) suggest that although low need satisfaction has the potential to hamper individuals' growth and well-being, the active frustration of psychological needs is likely to be especially harmful and uniquely predictive of ill-being. When basic psychological needs are frustrated people experience pressure to think, feel or act a certain way (autonomy frustration), experience feelings of failure of inadequacy (competence frustration), and feel socially isolated or excluded (relatedness frustration). Importantly, recent claims state that a lack of need satisfaction does not necessarily entail the presence of need frustration. Rather, need frustration is said to occur when needs are actively undermined or thwarted. To give an example, an individual may not feel particularly close or connected to someone (i.e., low relatedness satisfaction), but this does not necessarily mean that they feel actively excluded or rejected by that person (i.e., relatedness frustration).Thus, rather than being perfectly opposite from one another it is suggested that need satisfaction and need frustration are relatively distinct constructs with the potential to yield differential outcomes.

Supporting these claims, several studies have found need satisfaction and need frustration to be moderately (rather than perfectly) negatively correlated (Bartholomew et al., 2011; Haerens, Aelterman, Vansteenkiste, Soenens, & Van Petegem, 2015; Gillet, Fouquereau, Forest, Brunault, & Colombat, 2012). Furthermore, a rapidly growing number of studies have found need frustration to be uniquely predictive of negative outcomes, such as exhaustion, symptoms of depression (Bartholomew et al., 2011; Boone, Campbell, Vansteenkiste, & Soenens, in revision), anxiety and somatization (Cordeiro, Paixão, Lens, Lacante, & Luyckx, 2016), over and above a lack of need fulfilment. Such effects have emerged using both self-report and objective indicators of maladjustment. For example, need frustration has been shown to be associated with elevations in S-IgA, an immunological protein associated with the anticipation of acute stressors (Bartholomew et al., 2011). These findings are consistent with the notion that while need satisfaction is especially involved in fostering adaptive functioning, need frustration plays a critical role in eliciting maladaptive functioning (Ryan, Deci, & Vansteenkiste, 2016; Vansteenkiste & Ryan, 2013).

1.3. Relation between Psychological Needs and Physiological Needs

Apart from need-based experiences being implicated in individuals' psychological growth and well-being, a few studies suggest that the satisfaction and frustration of basic psychological needs also plays a role in the regulation of individuals' physiological needs. Specifically, previous studies have found need-based experiences to be involved in individuals' sexual experiences (Smith, 2007), as well as in the regulation of eating behavior (e.g., Schüler & Kuster, 2011; Bartholomew et al., 2011). For example, with regard to eating regulation a diary study found that on days that adolescent girls experienced more need frustration they were also more likely to report binge eating symptoms (Verstuyf, Vansteenkiste, Soenens, Boone, & Mouratidis, 2013). In addition, a longitudinal study among adolescents similarly found that increases in need frustration predicted increases in binge eating symptoms across time (Boone, Vansteenkiste, Soenens, van der Kaap-Deeder, & Verstuyf, 2014). As suggested by Verstuyf and colleagues (2013), given that need frustration has been linked to experiencing more negative affect (e.g., Bartholomew et al., 2011), disordered eating, and binge eating symptoms in particular, may result as a way to cope with the negative affect elicited by need frustration.

1.4. Identifying Gaps in the Literature

In sum, abundant previous research has demonstrated that the satisfaction of the basic psychological needs for autonomy, competence, and relatedness relates to enhanced well-being, whereas the frustration of these same needs is predictive of ill-being. However, only a few previous studies have examined whether need-based experiences are also implicated in the fulfillment (or deprivation) of physiological needs. Indeed, it seems plausible that emotional reactivity to experiences of need frustration may not only interfere with eating regulation, but could also obstruct the regulation of other physiological needs including individual's quality and quantity of sleep. This is presumably because negative affect resulting from need frustrating experiences is likely to prevent individuals from relaxing sufficiently to drift off into restful sleep at night. However, to the best of our knowledge no previous studies have examined whether basic psychological need experiences are indeed implicated in individuals' sleep.

Within the present dissertation we aimed to fill this gap in the literature by systematically examining whether the satisfaction and frustration of basic psychological needs would relate to diverse sleep-related outcomes. Given the lack of previous work examining the role of basic psychological needs in predicting sleep outcomes we began by examining these associations at both the between- and within-person level in non-clinical healthy samples. In addition, given that SDT's needs are claimed to be universal and therefore relevant across diverse clinical statuses, we further sought to examine whether the association between SDT's basic needs and sleep would extend to clinical populations in which physical health is compromised and sleep disturbances are highly prevalent. Specifically, we examined the need-sleep relation among individuals with Chronic Fatigue Syndrome (CFS) and people living with HIV (PLHIV).

2. Explanatory Mechanisms

Having observed that there is a lack of research examining the role of need-based experiences in predicting sleep outcomes, the question arises as to why the satisfaction and frustration of individuals' psychological needs might relate to individuals' quality and quantity of sleep. In other words, what are the underlying mechanisms which might explain the possible link between need-based experiences and sleep outcomes? In the present dissertation we examined two possible explanatory mechanisms, namely symptoms of stress such as nervous arousal, difficulty relaxing, and tension (Lovibond & Lovibond, 2004) as well as negative sleep-related thoughts such as worrying about the consequences of not getting enough sleep. These explanatory mechanisms were examined for two important reasons. First, because previous research suggests that experiences of need frustration are likely to engender both stress (Weinstein & Ryan, 2011) and dysfunctional cognitive processes like worrying and rumination (Van der Kaap-Deeder, Vansteenkiste, Van Petegem, Raes, & Soenens, 2016). Second, because theoretical models of insomnia (e.g., Espie, et al., 2006; Riemann, et al., 2010) and previous empirical studies (e.g., Morin, Rodrigue, & Ivers, 2003; Winzeler et al., 2014) have extensively argued and found evidence for the role of both stress and negative cognitive arousal in sleep disturbances.

2.1. Sleep-interfering Processes

2.1.1. Stress

Several models of insomnia posit sleep disturbances as arising from arousal processes which interfere with individuals' sleep (e.g., Espie, 2002; Espie et al 2006; Harvey, 2002; Riemann, et al 2010). It has been suggested that psychosocial stressors in particular may trigger cognitive and physiological arousal, which then in turn obstructs restful sleep (e.g., Espie et al 2006; Riemann et al., 2010). Accordingly, a number of studies have demonstrated that stress plays a role in sleep disturbances. For example, perceived stress was found to predict poor sleep among adolescents' (Fuligni & Hardway, 2006), university students (Lund et al., 2010), and adults (Akerstedt et al., 2012).

Furthermore, minor stressors or daily hassles such as work demands, family conflict and academic stress (Janson & Linton, et al., 2006; Bernert et al., 2007) as well as major stressful events such as illness or significant losses (e.g. death of divorce) have been implicated in the onset of chronic sleep disturbances (Healy et al., 1981; Vahtera et al., 2007).

2.1.2. Cognitive Processes

Apart from stress, cognitive processes are also posited to play a crucial role in sleep disturbances (e.g., Harvey, 2002; Lundh and Broman, 2000). In particular, it is proposed that excessive negatively toned cognitive activity at night, including rumination about the consequences of sleeplessness, may culminate in a real sleep deficit (Harvey, 2002). Several studies support the role of cognitive processes in sleep disturbances by demonstrating, for example, that across diverse cultures poor sleepers attribute their sleep disturbances to uncontrollable pre-sleep cognitive activity (Harvey, Gregory, & Bird, 2002). Other studies have attempted to uncover the nature of this pre-sleep cognitive activity and found that relative to good sleepers, individuals who suffer from sleep disturbances are more likely to report being focused on not being able to sleep, and less focused on ‘nothing in particular’ in the pre-sleep period (Harvey, 2000). Similarly, another study which monitored pre-sleep thoughts using a tape-recorder demonstrated that thinking about sleep and worrying about the consequences of not sleeping was a key predictor of subsequent sleep disturbance (Wicklow & Espie, 2000). Finally, a number of experimental studies further support the role of cognitive processes in sleep disturbances by demonstrating that deliberately induced cognitive arousal in general (i.e., not specifically related to sleep) results in delayed sleep onset among good sleepers (e.g., Gross & Borkovec, 1982; Wuyts, et al., 2012).

To the best of our knowledge, only a few studies have actually examined the interrelationship between stress, cognitive arousal processes and sleep disturbances. Specifically, Morin, Rodrigue, and Ivers (2003) found that daily stress contributed to more somatic arousal (i.e., jittery, nervous, tense feelings in the body) and cognitive arousal (i.e., uncontrollable thoughts, including rumination about sleeplessness), which then in turn related to poorer self-reported qualitative and quantitative sleep outcomes. Winzeler et al. (2014) replicated these findings by similarly demonstrating that daily stress related to poorer subjective sleep quality via the same pre-sleep arousal processes. These findings are consistent with the idea proposed by Riemann and colleagues (2010) that stressful life events may “set the wheel in motion” causing hyperarousal with sleep disruption.

2.2. Identifying Gaps in the Literature

Importantly, previous research suggests that psychological need-frustrating experiences present a risk factor for stress incursion and poor stress response (for an overview see Weinstein & Ryan, 2010). For example, one study demonstrated that dancers who reported higher psychological need satisfaction exhibited a lower stress response during performance conditions (Quested et al., 2011). In addition, experimental studies found that psychological need frustration resulting from exposure to a controlling teaching (Reeve & Tseng, 2011) or coaching (DeMuynck, et al., 2017) style was associated with elevations in stress. Furthermore, a recent diary study among parents of elementary school children found that on days that parents experienced more need frustration, they also reported higher symptoms of stress when interacting with their child (Van der Kaap-Deeder et al., in revision) Apart from being implicated in individuals’ stress response, need frustrating experiences have also been shown to elicit more ruminative thinking (Van der Kaap-Deeder et al., 2016).

In light of this evidence suggesting that need frustration is implicated in stress reactivity and dysfunctional cognitive processes, it seems plausible that experiences of need frustration may spark a maladaptive pattern of stress and subsequent negative cognitive arousal which in turn may contribute to sleep disturbances. However, to the best of our knowledge no studies have examined whether need frustration contributes to poor sleep via stress and dysfunctional cognitive processes. Furthermore, although a large number of previous studies have demonstrated that both stress and negative sleep-related cognitions play a role in sleep disturbances, as far as we are aware no previous studies have adopted a theory-driven approach to identify specific factors which are at the root of this maladaptive pattern. The present dissertation aimed to address these gaps by examining the explanatory role of stress and negative sleep-related cognitions in the relation between need-based experiences and diverse sleep outcomes. This issue was explored in both non-clinical samples (i.e., adolescents and university students) as well as a clinical sample at risk for poor sleep (i.e., patients with unexplained chronic fatigue).

3. The Role of Mindfulness

If experiences of need frustration do indeed spark a negative spiral of stress, cognitive arousal and poor sleep, then it is important to consider how need-fulfillment can be promoted as a means to prevent this maladaptive pattern from occurring. While an extensive body of research has focused on the role of social-contextual factors (i.e., within one's external environment) in facilitating the satisfaction of individuals' basic psychological needs (Deci & Ryan, 2000), all individuals also possess inherent capacities to act in the service of their own need satisfaction, even in spite of need-thwarting social contexts (Ryan & Deci, 2017). In the present dissertation we focus on individuals' quality of awareness, and in particular on the capacity to be mindful, as a foundation for promoting psychological need satisfaction.

Mindfulness is described as an open, receptive awareness to internal and external present moment experiences (Brown & Ryan, 2003). Acting mindfully involves paying attention in the present moment, nonjudgmentally, to experiences as they unfold (Kabat-Zinn, 2003). There has been an exponential growth of interest in mindfulness within the scientific community (see Brown, Creswell, & Ryan, 2016 for an overview) because an increasing number of studies indicate that being mindful is beneficial to both physical (e.g., Davidson et al., 2003; Riebel, Greeson, Brainard, Rosenweig, 2001) and psychological health (e.g., Chiesa, & Serretti, 2009; Vollestad, Nielsen, & Nielsen, 2012). This is presumed to be because the observant stance characteristic of mindfulness likely discourages automatic dysfunctional thought patterns and behaviors, which in turn may promote better psychological states and facilitate enhanced self-regulation (Brown, Ryan & Creswell, 2007). Fortunately, all individuals possess an inherent capacity to be mindful which can be cultivated through meditation practice (Kabatzin, 2003), as is evidenced by significant increases in dispositional mindfulness following mindfulness-based interventions (e.g., Creswell et al., 2012).

3.1. Mindfulness and Sleep

Of particular relevance to the present dissertation, an increasing number of studies suggest that mindfulness facilitates better sleep. For example a few correlational studies among university students (Howell, et al., 2010; Howell, et al., 2008) and older adults (Visser, Hirsch, Brown, Ryan, & Moynihan, 2014) demonstrated that individuals higher in dispositional mindfulness reported better sleep outcomes. Furthermore, several mindfulness-based intervention studies have reported positive effects on individuals' sleep. To give just one example, a mindfulness-based stress reduction intervention was found to have a positive effect on sleep quality among individuals with breast and prostate cancer (Carlson, Speca, Patel & Goodey, 2004). A recent meta-analysis of mindfulness-based interventions for sleep found them to be associated with shorter sleep latency and reduced wake after sleep onset as well as increased sleep efficiency and total sleep time (Kanen, Nazir, Sedky, & Pradhan, 2015). Notably, both teacher-led and more intensive mindfulness-based stress reduction programs (Lengacher et al., 2015) as well as self-administered and more time- and cost-effective mindfulness interventions (Hülsheger, Feinholdt, & Nübold, 2015) have been found to yield such benefits.

3.2. Identifying Gaps in the Literature

Several scholars have speculated about why it is that mindfulness relates to better sleep. For example, mindfulness has been said to promote letting go of dysfunctional beliefs and attitudes towards sleep, as well as acceptance when not being able to sleep (Kabatzin, 1990). Similarly, Lundh (2005) argued that mindfulness may help to foster a more accepting approach to spontaneously occurring physical and psychological processes, which may facilitate better sleep. More recently, Ong and colleagues (2015) proposed that by promoting a change in the relationship with one's thoughts (rather than the content of one's thoughts) mindfulness helps to shift one's perspective thereby facilitating adaptive responses rather than emotional reactivity, which in turn is conducive to better sleep. However, to the best of our knowledge no empirical studies have actually sought to identify the specific mechanisms which explain the relation between mindfulness and sleep.

Apart from mindfulness promoting better acceptance to thoughts and bodily sensations during the *pre-sleep period*, another possibility is that mindfulness may relate to better sleep outcomes by facilitating the satisfaction of basic psychological needs *throughout the day*. Need satisfaction, in turn, may then facilitate relaxation (or de-arousal) and better sleep at night. There are several possible ways through which mindfulness may relate to enhanced need satisfaction. First, mindful individuals are less likely to react to need-thwarting situations in automatic (maladaptive) ways. Rather, when confronted with need frustrating experiences, mindful individuals are likely to first "take stock" as a means to ensure that their behavior is congruent with their values, thereby minimizing the resulting need frustration and perhaps even promoting need satisfaction. Second, the open receptive awareness characteristic of mindfulness likely facilitates individuals' to whole-heartedly and more effectively engage in daily activities, such that more need satisfaction is derived. Third, when mindful people are likely to be more in tune with their interests and values which may lead them to more proactively engage in and select need satisfying activities, as well as to be more responsive to cues and opportunities for need satisfaction throughout the day. In line with this reasoning, one previous study found mindfulness to be associated with higher need satisfaction (Brown & Ryan, 2003). However, no previous studies have examined the possible explanatory role of need satisfaction in the relation between mindfulness and sleep-related outcomes.

In sum, the findings of several correlational and intervention-based studies suggest that being mindful is likely to facilitate better sleep outcomes and that conversely; not acting mindfully is likely to leave individuals vulnerable for poor sleep. However, little is known about the mechanisms which account for these associations. In the present dissertation we sought to examine whether mindfulness would relate to diverse sleep-related outcomes through (i.e., accounted for by) psychological need satisfaction. Specially, we examined whether need satisfaction would play an explanatory role in the relation between mindfulness and sleep-related outcomes in a non-clinical healthy sample (i.e., healthy adults) as well as a clinical sample in which sleep disturbances are highly prevalent (i.e., people living with HIV).

4. Reciprocal and Causal Relation between Sleep and Psychological Functioning

Apart from psychological factors playing a role in either facilitating or obstructing sleep, there is a rich body of evidence which suggests that sleep at night is also likely to impact on individuals' functioning (e.g., Frenda & Fenn, 2016; Harrison & Horne, 2000; Pires, Bezerra, Tulfik, & Andersen, 2016). This evidence has largely been provided by two different types of studies, namely diary studies and experimental studies. Below we briefly review the evidence generated by both types of studies.

4.1. Reciprocal Relations

A few diary studies among both non-clinical and clinical populations have demonstrated that daily experiences are not only predictive of, but are also predicted by quality and quantity of sleep at night. For example, diary studies among adolescents' have demonstrated that shorter self-reported sleep duration related to more fatigue and feelings of anxiety and depressive symptoms (Fuligni & Hardway, 2006), as well as less socializing with friends throughout the following day (Galambos, Dalton, Maggs., 2009). In addition, poorer subjective sleep quality was related to more daily negative affect and less daily positive affect (Galambos et al, 2009). Diary studies among adults have demonstrated similar findings with poorer daily subjective sleep quality and more self-reported awakenings throughout the night relating to less positive affect upon awakening in the morning (McCrae et al., 2008; Sonnentag, Binnewies, & Mojza, 2008). These reciprocal day-to-day associations between sleep and daily experiences are not limited to non-clinical samples and also extend to clinical samples in which sleep disturbances are highly prevalent. To provide just one example, a diary study among patients with Chronic Fatigue Syndrome (CFS) showed that poorer self-reported sleep at night related to higher fatigue the following day (Russell et al, 2016).

4.2. Causal Relations

While diary studies allow for the close examination of the *reciprocal* day-to-day association between sleep and daily experiences in an ecologically valid way, they do not allow for *causal* inferences. Specifically, findings from diary studies cannot rule out the possibility that a third variable may relate to daily experiences above and beyond sleep, thus preventing conclusions about the direction of effects from being drawn. For causal relations to be established experimental designs which manipulate sleep and observe the effects on individuals functioning are needed.

Indeed, a large number of experimental studies have already provided evidence for the causal impact of sleep, and sleep duration in particular, on individuals functioning. This evidence has largely been derived from experimental sleep deprivation studies which have examined the effects of induced sleep debt on a variety of outcomes. Typically, these studies have either involved examining the effects of total sleep deprivation (i.e., total sleep loss for 24 hours; e.g., Klumpers, et al., 2015) or partial sleep deprivation (i.e., sleeping less than 7 hours a night; e.g., Wells & Cruess, 2017) on indicators of physiological or psychological functioning. Overall, the results of these studies have consistently demonstrated that sleep deprivation comes with a significant cost, as is evidenced by the detrimental impact of induced sleep debt on a wide-range of outcomes.

The physiological effects of sleep deprivation include reduced energy (e.g., Klumpers et al., 2015; Minkel et al., 2014), impairments in cardiovascular health (e.g., Meier-Ewert et al., 2004), immune function (e.g., Wilder-Smith et al., 2013), and glucose metabolism (e.g., Spiegel, Leproult, & Van Cauter, 1999) as well as elevated levels of the stress hormone cortisol (Minkel et al., 2014). Apart from these physiological consequences, sleep deprivation has also been shown to affect psychological functioning and result in mood disturbances (e.g., Kahn-Greene, Killgore, Kamimori, Balkin, & Killgore, 2007), anxiety (e.g., Pires et al., 2016), and cognitive dysfunction (e.g., Frenda & Fenn, 2016). For example, with regard to cognitive dysfunction insufficient sleep has been shown to negatively impact attention (Harrison & Horne, 2000) and memory (Yoo, Hu, Gujar, Jolesz, & Walker, 2007) as well as moral judgement and decision making (e.g., Killgore et al., 2006; Killgore et al., 2007).

4.3. Identifying Gaps in the Literature

Although previous diary studies have provided evidence for the reciprocal association between sleep and individuals' daily experiences, and affective experiences in particular, no previous studies have examined whether quality and quantity of sleep at night also contributes to individuals' daily need-based experiences. Indeed, because of the restoration and energy that sleep provides, after a night of sufficient, good quality sleep, individuals may be more able to engage in and select need-satisfying activities as well as more equipped to handle any encountered need frustrating experiences. In line with this reasoning, experimental sleep deprivation studies indicate that insufficient sleep is likely to lead to depleted energy (e.g., Klumpers, et al., 2015), and difficulties focusing (e.g., Poh et al., 2016), thereby suggesting that following poor sleep individuals are likely to struggle to effectively engage in valued everyday activities, including socializing with friends and family, thus precluding need satisfaction. Throughout the present dissertation we sought to examine this issue of reciprocity through both diary and experimental designs. First, we conducted diary studies among both non-clinical (i.e., among adolescents) and clinical (i.e., among CFS patients) samples, which allowed us to examine the reciprocal day-to-day association between need-based experiences and quality and quantity of sleep. Second, to establish causal relations, we conducted an experimental sleep deprivation study among healthy adults to examine whether induced sleep debt would result in poorer need-based functioning.

Interestingly, previous experimental studies also provide some evidence that individuals' capacity to be mindful is likely to be impaired by sleep deprivation. For example, partial sleep deprivation (i.e., sleeping 5 hours a night) has been shown to increase distractibility during monotonous tasks (Anderson & Horne, 2006), whereas total sleep deprivation (i.e., total sleep loss for 24 hours) has been demonstrated to result in increased mind wandering (i.e., having task-unrelated thoughts) during subsequent visual tasks (Poh, Chong, & Chee, 2016). However, although a number of previous studies indicate that low mindfulness is likely to precede poor sleep, to the best of our knowledge no studies have directly examined whether insufficient sleep impairs individuals' capacity to be mindful. Thus in our experimental sleep deprivation study we not only examined effects on need-based functioning, but also examined whether the induced sleep debt would impact on individuals' capacity to be mindful.

5. Research Objectives and Outline of the Dissertation

Based on the identification of these various gaps in the literature, we established five objectives which were pursued throughout the current dissertation (see Figure 1 for a graphical representation of the objective pursued within the present dissertation). These were (1) to examine the relation between need-based experiences and sleep at the between- and within-person level, (2) to examine whether these associations would generalize to clinical populations in which sleep disturbances are highly prevalent, (3) to examine stress and negative sleep-related cognitions as explanatory processes in the relation need-based experiences and sleep, (4) to collect evidence for the reciprocal and causal relation between need-based experiences and sleep outcomes, and (5) to examine whether mindfulness relates to sleep outcomes via need satisfaction.

In pursuing these objectives we adopted a differentiated and multi-method approach to measuring sleep, thereby assessing both quantitative and qualitative aspects of sleep, as well as employing both subjective (i.e., self-report questionnaires, e.g., Buysse et al., 1989; Monk et al., 1994) and objective sleep measures (i.e., polysomnography & wrist actigraphy e.g., Iber, Ancoli-Israel, Chesson, & Quan, 2007; Sadeh, 2011). Furthermore, in line with existing measures which are commonly used to assess sleep (i.e., Pittsburgh Sleep Quality Index; Buysse et al., 1989) we not only assessed qualitative and quantitative aspects of sleep, but also more daytime related indicators of energy and exhaustion (e.g., fatigue, vitality; Watson et al., 2007; Ryan & Fredericks, 1997). As noted in the introductory paragraphs, we deemed it important to adopt a heterogeneous approach to measuring sleep and opted to distinguish between qualitative, quantitative and daytime-related sleep outcomes, rather than combining several indicators into a sleep composite score as has sometimes been done in past research (e.g., Carmichael & Reis, 2005; Howell et al., 2008). The reason for this choice was that psychological factors may relate differentially to different facets of sleep and the use of global composite scores prevents the examination of whether psychological predictors yield equal or differential relations to diverse sleep indicators.

As shown in Table 1 a variety of designs (i.e., cross-sectional, diary, & experimental) and samples (i.e., non-clinical and clinical) were used to examine these five objectives, which were pursued throughout a series of eight studies. Each of the conducted studies pursued multiple objectives, such that, as a whole they realized the five objectives. Throughout the eight studies described within the present dissertation we tried to build a cumulative logic by gradually (a) using more sophisticated designs (b) sampling individuals from diverse non-clinical and clinical groups and (c) moving beyond self-report assessments of sleep to also include objective sleep measures. In the following sections we specify in more detail how each of the objectives was pursued throughout the empirical chapters contained within the present dissertation.

5.1. Objective 1: To Examine the Relation between Psychological Need-Based Experiences and Diverse Sleep Outcomes at both the Between- and Within-Person Level.

Given the lack of previous studies investigating the role of psychological need-based experiences in predicting sleep outcomes, our first objective was to examine the hypothesized associations at both the between- and within-person level in non-clinical samples. In **Chapter 2**, we began by conducting a cross-sectional questionnaire study among a sample of healthy adults (*N* = 215) to examine the relation between need-based experiences and diverse sleep-related outcomes between individuals. We hypothesized that individuals who were more need satisfied would report better sleep quality and less daytime dysfunction, and possibly also longer sleep duration.

Next, we moved from an inter-personal to an intra-personal approach, thereby examining whether the hypothesized need-sleep association would also apply at the within-person level. In **Chapter 3**, we conducted a short-term longitudinal study among emerging adults (N = 121), involving three measurements moments centred around a potentially stressful period (i.e., an exam period). More specifically, we assessed emerging adults' need based experiences and sleep-related functioning before, during, and after the exam period. We began by examining the mean level change in these outcomes as participants went through this potentially stressful period. We expected negative outcomes (i.e., need frustration & poor sleep quality) to increase from the pre- to the exam period and decrease from the exam to the post exam period. The opposite pattern was expected for positive outcomes (i.e., need satisfaction & sleep quantity). Apart from inspecting these mean level changes we also examined the co-variation between within-person changes in need-based experiences and within-person changes in the sleep-related outcomes across the measurement moments. Specifically we examined whether within-person changes in need-based experiences and within-person changes in sleep-related outcomes would occur in tandem from one measurement moment to the next. We hypothesized that from the pre- to the exam-period deterioration in need-based experiences would be accompanied by poorer sleep-related functioning, and that from the exam- to the post-exam period improvements in need-based functioning would go hand in hand with better sleep-related outcomes.

Finally, in **Chapter 7** we continued to investigate the hypothesized need-sleep dynamics at the within-person level, this time using a diary design in which adolescents (Study 1: N = 211; Study 2: N = 51) were assessed for 8 consecutive days. Diary designs allow for the close examination of dynamic daily processes in an individuals' natural environment thereby increasing the ecological validity of the findings. Furthermore, because participants provide assessments every day, measurement error due to biased retrospective recall is minimized (Bolger et al., 2003). Importantly, using a diary design allowed us to examine whether day-to-day variation in need-based experiences would relate to day-to-day variation in sleep-related outcomes. Furthermore, we not only examined the day-to-day relation between need-based experiences and self-reported sleep outcomes but also examined whether these relations would extend to an objective measure of sleep, namely objective sleep quantity, as measured by wrist actigraphy. We hypothesized that adolescents who had more need frustrating experiences during the day would report poorer quality and shorter quantity sleep at night. Finally, we also expected more need frustrating daily experiences to drain adolescents of energy and thus relate to more daily fatigue.

5.2. Objective 2: To Examine whether the Observed Findings Generalize to Clinical Groups in which Sleep Disturbances are Highly Prevalent.

Given that SDT's basic psychological needs are claimed to be universal and are therefore said to foster adaptive functioning (when satisfied) and bring about maladaptive functioning (when frustrated) among all individuals regardless of their background or clinical status (Ryan & Deci, 2017), our second objective was to examine whether the hypothesized need-sleep association would also generalize to clinical populations. Indeed, one might argue that psychological factors only play a role among healthy individuals' and make no difference among individuals whose physical functioning is severely impaired. Thus, we were interested to examine whether the need-sleep relation would indeed extend to clinical groups in which physical functioning is compromised and sleep disturbances are also highly prevalent.

In **Chapter 4** we began by conducting a cross-sectional questionnaire study among people living with HIV (PLHIV; N = 101). Given that health-related quality of life (HRQOL) is a central outcome among PLHIV (Lin et al., 2002), and that previous research has consistently linked need-based experiences to indicators of well-being (e.g., Deci & Ryan, 2000; Chen et al., 2015), in this study we began by examining whether need-based experiences would relate to physical and mental health among PLHIV. Subsequently, we examined whether the hypothesized relation between need-based experiences and the indicators of HRQOL would be accounted for by quality and quantity of sleep. We hypothesized that need-based experiences would relate to better health-related quality of life through (i.e., accounted for by) quality and possibly also quantity of sleep.

Next, in **Chapter 5**, we conducted a prospective cross-sectional study among individuals who were undergoing clinical investigation for complaints of unexplained chronic fatigue (N = 160) during a stay at a sleep laboratory. This provided us with the opportunity to examine whether need-based experiences during the past week would be predictive of both subjective and objective sleep-related outcomes, the latter of which was assessed using polysomnography. This allowed us to examine whether the relation between need-based experiences and sleep would also extend to objective sleep parameters among a severely fatigued clinical sample.

Finally, in **Chapter 6** we examined whether the relation between need-based experiences and sleep-related outcomes would also apply at the within-person level among individuals with Chronic Fatigue Syndrome (CFS). To examine these within-person associations we conducted a diary study among CFS patients (N = 90) in which patients were assessed for 14 consecutive days. Given that enduring fatigue is the predominant complaint among individuals with CFS, and that psychological need-based experiences have previously been shown to be implicated in individuals' energy levels (Ryan & Deci, 2008; Chen et al., 2015), our central focus in this study was on examining whether day-to-day variation in need-based experiences would contribute to day-to-day variation in subjective energy. We then went on to examine whether daily variation in need-based experiences would also relate to day-to-day variability in CFS patients' quality and quantity of sleep. Similar to the diary study carried out among adolescents, we hypothesized that on days that CFS patients' experienced more need frustrating experiences, they would also report less subjective energy, manifested through higher fatigue and less vitality. In addition, we expected that the more patients reported need frustrating experiences from day-to-day, the more they would be prone to poorer quality and possibly also reduced quantity of sleep because these experiences would likely engender more stress and cognitive arousal at bedtime which would obstruct restful sleep at night.

5.3. Objective 3: To Explore Stress and Negative Sleep-related Cognitions as Explanatory Processes.

In line with previous models of chronic sleep disturbances (e.g., Espie et al 2006; Riemann et al., 2010), which posit stress and negative cognitive arousal to play a role in precipitating and maintaining poor sleep, our third objective was to examine whether stress and negative sleep-related cognitions would play an explanatory role in the need-sleep relation. As noted above, in **Chapter 3** emerging adults (N = 121) were followed as they went through a stressful period. Apart from assessing their need-based experiences and sleep repeatedly, we also included a measure of their experienced stress. This allowed us to examine whether within-person changes in stress would account for the association between within-person changes in need-based experiences and within-person changes in sleep-related outcomes. We hypothesized that from the pre- to the exam period increases in stress would account for the relation between deterioration in need-based experiences and poorer sleep-related functioning, whereas from the exam- to the post-exam period we expected decreases in stress to account for the relation between improved need-based experiences and better sleep-related functioning.

In **Chapter 7** we continued to examine the explanatory role of symptoms of stress in the need-sleep relation, this time using a diary design. Indeed, stress not only varies around stressful periods, but may also vary from day to day, with individuals' sleep co-varying with these daily fluctuations in stress. Specifically, in a diary study among adolescents (Study 2: N = 51) we examined whether day-to-day variation in symptoms of stress would account for the day-to-day association between need-based experiences and sleep-related outcomes. We hypothesized that on days that adolescents experienced more need frustrating experiences they would report more symptoms of stress, which in turn would erode energy levels and contribute to more daytime fatigue, as well as obstruct sleep at night thereby also relating to poorer sleep quality and shorter sleep quantity.

While in **Chapters 3 and 7** we only focused on the explanatory role of symptoms of stress, in **Chapter 5** we considered the explanatory role of both stress *and* negative sleep-related cognitions in the relation between need-based experiences and sleep outcomes among individuals with unexplained chronic fatigue (*N* = 160). In line with our hypothesized model (see Figure 1), we expected need frustrating experiences to relate to higher stress. In turn, we expected stress to relate to more negative sleep-related cognitions. Finally, we expected that negative sleep-related cognitions in turn would relate to poorer sleep quality and shorter sleep quantity.

5.4. Objective 4: To Collect Evidence for the Reciprocal and Casual Relation between Psychological Need-Based Experiences and Sleep Outcomes.

Given the abundance of research which indicates that sleep is also likely to contribute to psychological functioning, our fourth objective was to examine the reciprocal and causal relation between psychological need-based experiences and sleep outcomes. First, we began by examining the *reciprocal* relation between need-based experiences and sleep outcomes in the daily flow of life through diary designs. Specifically, in **Chapter 6** and **Chapter 7** we conducted three diary studies among adolescents (Study 1: *N* = 211, Study 2: *N* = 51) and individuals with Chronic Fatigue Syndrome (*N* = 90), in which we not only examined whether need-based experiences would predict sleep at night, but also examined whether quality and quantity of sleep at night would contribute to need-based experiences the following day. Across both Chapters we expected poorer daily sleep quality and shorter daily sleep quantity to contribute to more need frustrating experiences the following day.

Finally, in **Chapter 8** we examined the *causal* impact of insufficient sleep on psychological functioning by conducting an experimental study among healthy adults (*N* = 49) in which participants were partially sleep deprived (i.e., slept less than 5 hours for three consecutive nights). This allowed us to draw casual inferences about the impact of induced sleep debt on psychological functioning (psychological need-based experiences & mindfulness). We expected the induced sleep deprivation to have a main effect on individuals' need-based experiences and their capacity to be mindful (as indexed by reduced need satisfaction and increased need frustration as well as by impaired mindfulness).

5.5. Objective 5: To Examine whether Mindfulness Relates to Sleep Outcomes via Need Satisfaction.

Our fifth and final objective was to build on previous research which found mindfulness to display a salutary relation with sleep outcomes (e.g., Howell, et al., 2010; Howell, et al., 2008; Visser et al., 2014) by examining whether need satisfaction would play an explanatory role in the relation between mindfulness and diverse sleep outcomes. In **Chapter 2** and **Chapter 4** we examined whether need satisfaction would account for (i.e., explain) the relation between trait-differences in mindfulness and sleep. This issue was examined in two cross-sectional questionnaire studies, one conducted among healthy adults (N = 215) and one conducted among people living with HIV (N = 101). We hypothesized that mindfulness would relate to less daytime dysfunction, better quality sleep and possibly also longer sleep duration through (i.e., accounted for by) through higher psychological need satisfaction.

In addition, given that sleep and psychological functioning are likely to be reciprocally related in **Chapter 8** we examined whether sleep would reciprocally predict mindfulness and subsequent need-based experiences. This was done in an experimental study among healthy adults (N = 49), in which we examined the role of experimentally induced sleep debt in predicting state differences in mindfulness. Specifically, we examined whether impaired mindfulness would account for the relation between experimentally induced sleep deprivation and poorer need-based experiences. We hypothesized that sleep deprivation would relate to impaired mindfulness which would then in turn relate to worse need-based experiences.

5.6. Additional Considerations

As the reader will notice, in some empirical chapters we examined the role of a composite score of need satisfaction in predicting outcomes, whereas in other chapters we examined whether need satisfaction and need frustration would relate differentially to the outcomes of interest. In some cases this decision was justified by the nature of the outcomes which were examined, whereas in other cases this decision was informed by the particular sample being studied, or the readership of the journal to which the empirical chapter was submitted. Furthermore, in some chapters we also went one step further and examined the unique contributions of each of the separate needs (i.e., for autonomy, competence and relatedness) in the prediction of the outcomes. However, in general we opted not to examine the differential role of each of the separate needs for conceptual and methodological reasons. First and most importantly, at a conceptual level, we did not have any specific hypotheses regarding the differential role of autonomy, competence, and relatedness, in predicting sleep outcomes. The reason for this being that SDT regards each of the three needs as being equally essential for optimal functioning and well-being, and we had no reason to believe that any particular need would be more strongly (or weakly) related to the sleep-related outcomes. Second, at a methodological level, the three needs are often highly correlated (e.g., Chen et al., 2015; Chen, Van Assche, Vansteenkiste, Soenens & Beyers, 2014) which raises issues of multicollinearity when examining the unique contribution of each separate need.

Figure 1

Graphical representation of the objectives of the dissertation

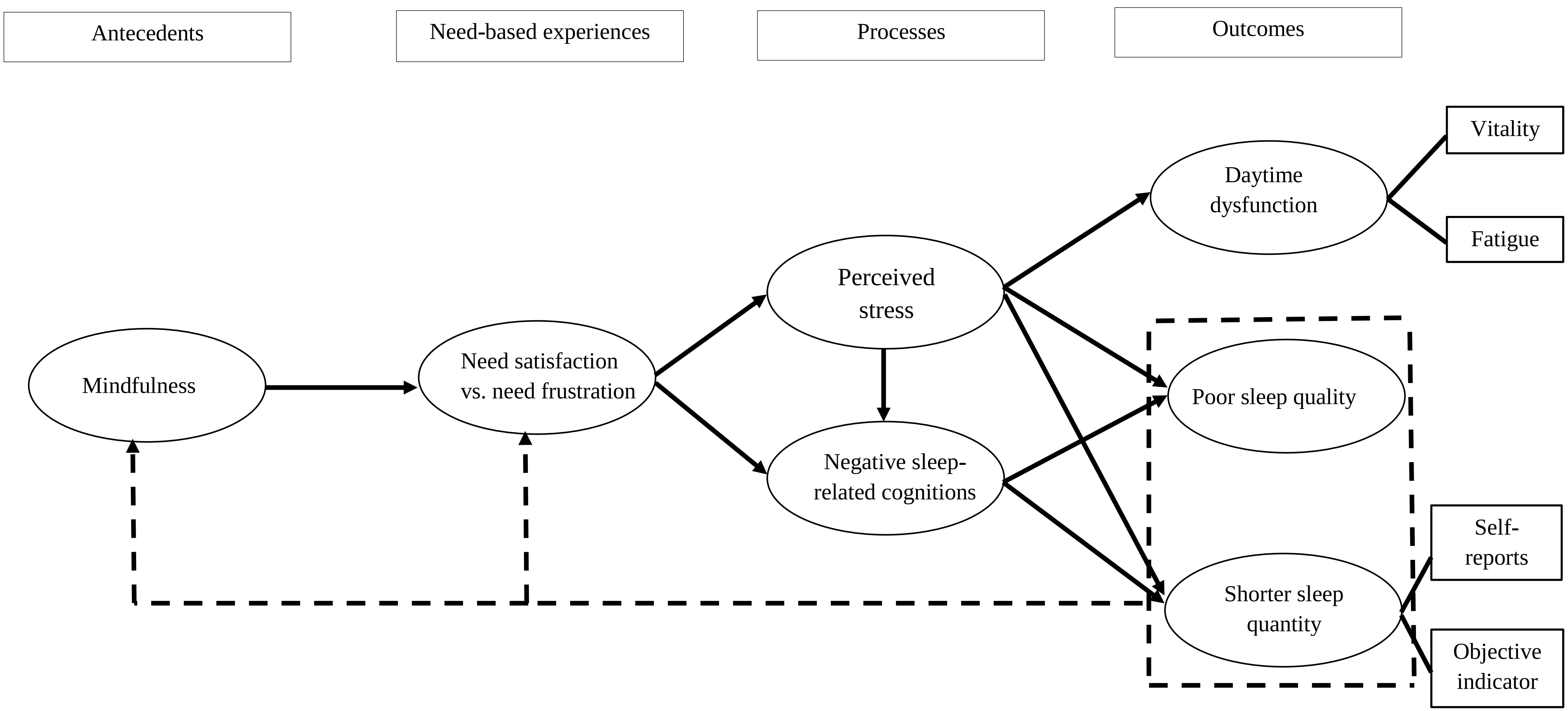


Table 1

Overview of empirical studies

Chapter	**Studies**	**Objectives**	**Design**	**Total *N***	**Sample**	***M* age (years)**	**Gender (% female)**	**Measure of sleep**	**Analytical Technique**
Chapter 2	Study 1	1 & 5	Cross-sectional	215	Non-clinical	31	61	Self-report	SEM
Chapter 3	Study 2	1 & 3	Longitudinal	121	Non-clinical	21.69	78	Self-report	Latent change modeling
Chapter 4	Study 3	2 & 5	Cross-sectional	101	Clinical	45.48	16	Self-report	SEM
Chapter 5	Study 4	2 & 3	Cross-sectional	160	Clinical	39.63	78	Self-report/objective	SEM
Chapter 6	Study 5	2 & 4	Diary study	90	Clinical	42.10	92	Self-report	Multilevel regression
Chapter 7	Study 6	1 & 4	Diary study	211	Non-clinical	15.86	52	Self-report	Multilevel regression
	Study 7	1, 3 & 4	Diary study	51	Non-clinical	15.88	49	Self-report/objective	Multilevel regression
Chapter 8	Study 8	4 & 5	Experimental	49	Non-clinical	32.81	77	Objective	Repeated measures ANOVA; Latent change modeling

Note. ANOVA = analysis of variance; SEM = structural equation modeling

6. References

Ahmad I., Vansteenkiste M., Soenens B. (2013). The relations of Arab Jordanian adolescents' perceived maternal parenting to teacher-rated adjustment and problems: The intervening role of perceived need satisfaction. *Developmental Psychology*, *49*, 177–183

Akerstedt, T., Orsini, N., Petersen, H., Axelsson, J., Lekander, M., & Kecklund, G. (2012). Predicting sleep quality from stress and prior sleep – a study of day-to-day covariation across six weeks. *Sleep Medicine, 13,* 674-679.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Publishing.

Anderson, C., & Horne, J. A. (2006). Sleepiness enhances distraction during a monotonous task. *Sleep, 29*, 573-576.

Atkinson, J. W. (1958). *Motives in fantasy, action and society*. Princeton, NJ: Van Nostrand.

Aziz, M., Younus, A., Malik, R., Rouseff, M., Das, S., Guzman, H., Maziak, W., Virani, S ., Feldman, T., Agatston, A.S., Veledar, E., Aneni, E.C., & Nasir, K. The association of sleep duration and morbid obesity in a working population: The Baptist health South Florida employee study. *Metabolic Syndrome and Related Disorders*, 15(2), 59-62.

Bartholomew, K. J., Ntoumanis, N., Ryan, R. M., & Thøgersen-Ntoumani, C. (2011). Psychological need thwarting in the sport context: Assessing the darker side of athletic experience. *Journal of Sport & Exercise Psychology, 33,* 75-102.

Baum, K.T., Desai, A., Field, J., Miller, L. E., Rausch, J., & Beebe, D.W. (2014). Sleep restriction worsens mood and emotion regulation in adolescents. *The Journal of Child Psychology and Psychiatry*, 55 (*2*), 180-190.

Bernert, R.A., Merrill, K.A., Braithwaite, S.R., Van Orden, K.A., & Joiner Jr, T.E. (2007). Family life stress and insomnia symptoms in a prospective evaluation of young adults. *Journal of Family Psychology, 21,* 58-66.

Bolger, N., Davis, A., & Rafaeli, E. (2003). Diary methods: Capturing life as it is lived. *Annual Review of Psychology, 54,* 579 – 616.

Boone, L., Campbell, R., Vansteenkiste, M., & Soenens, B. (under revision). Psychological need frustration as a transdiagnostic process in associations of self-critical perfectionism with depressive symptoms and eating pathology. *Manuscript under revision for Journal of Clinical Psychology*.

Boone, L., Vansteenkiste, M., Soenens, B., van der Kaap-Deeder, J., & Verstuyf, J. (2014). Self-critical perfectionism and binge eating symptoms: A longitudinal test of the intervening role of psychological need frustration. *Journal of Counseling Psychology, 61,* 363-373.

Brown, K. W., Creswell, J. D., & Ryan, R. M. (Eds.). (2015). *Handbook of mindfulness: Theory, research, and practice*. Guilford Publications.

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology, 84*, 822–848. doi: 10.1037/0022-3514.84.4.822

Brown, K.W., & Ryan, R.M., & Creswell, J.D. (2007). Mindfulness: Theoretical foundations and evidence for its salutary effects. *Psychological Inquiry, 18*(4), 211-237.

Burgard, S.A. & Ailshire, J. A. (2009). Putting work to bed: Stressful experiences on the job and sleep quality. *Journal of Health and Social Behaviour, 50*, 476-492.

Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R. & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index – a new instrument for psychiatric practice and research. *Psychiatry Research, 28*, 193-213.

Carlson, L.E., Speca, M., Patel, K.D. & Goodey, E. (2004). Mindfulness-based stress reduction in relation to quality of life, mood, symptoms of stress and levels of cortisol, dehydroepiandrosterone sulfate (DHEAS) and melatonin in breast and prostate cancer outpatients. *Psychoneuroendocrinology, 29(4)*, 448-474.

Carmichael, C. L., & Reis, H. T. (2005). Attachment, sleep quality and depressed affect. *Health Psychology*, *24*, 526-531.

Chen, B., Van Assche, J., Vansteenkiste, M., Soenens, B., & Beyers, W. (2014). Does psychological need satisfaction matter when environmental or financial safety are at risk? *Journal of Happiness Studies, 16* (3), 745-766.

Chen, B., Vansteenkiste, M., Beyers, W., Boone, L., Deci, E. L., Duriez, B. Lens, W., Matos, L., Mouratidis, A., Ryan, R. M., Sheldon, K. M., Soenens, B., Van Petegem, S., & Van der Kaap-Deeder, J., Verstuyf, J (2015). Basic psychological need satisfaction, need frustration, and need strength across four cultures. *Motivation and Emotion*, *39*, 216-236.

Chiesa, A., & Serretti, A. (2009). Mindfulness-based stress reduction for stress management in healthy people: A review and meta-analysis. Journal of Alternative and Complimentary Medicine, 15, 593-600.

Cohen, S., Doyle, W.J., Alper, C.M., Janicki-Deverts, D., & Turner, R.B. (2009). Sleep habit and susceptibility to the common cold. *Archives of Internal Medicine*, 169(*1*), 62-67.

Cordeiro, P., Paixao, P., Lens, W., Lacante, M., & Luyckx, K (2016). The portuguese validation of the basic psychological need satisfaction and frustration scale: Concurrent and longitudinal relations to well-being and ill-being. *Psychologica Belgica, 56(3)*, 193-209.

Creswell, J. D., Irwin, M. R., Burklund, L. J., Lieberman, M. D., Arevalo, J. M., Ma, J., Breen, E.C., & Cole, S.W. (2012). Mindfulness-based stress reduction training reduces loneliness and pro-inflammatory gene expression in older adults: a small randomized trial. *Brain, Behavior, and Immunity*, 26:1095–1101.

Davidson, R. J., Kabat Zinn, J., Schumacher, J., Rosenkranz, M., Muller, D., Santorelli, S. F. & Sheridan, J. F. (2003). Alterations in brain and immune function produced by mindfulness meditation. *Psychosomatic Medicine*, *65*,564-570.

Deci, E.L., & Ryan, R.M. (1985). *Intrinsic motivation and self-determination in human behavior*. New York: Plenum Press.

Deci, E. L. & Ryan, R. M. (2000). The ‘what’ and ‘why’ of goal pursuits: Human needs and the self determination of behavior. *Psychological Inquiry*, *11*, 227-268.

Espie, C.A. (2002). Insomnia: Conceptual issues in the development, persistence, and treatment of sleep disorder in adults. Annual Review of Psychology, *53*, 215-243.

Espie, C.A., Broomfield, N.M., MacMahon, K.M., Macphee, L.M., Taylor, L.M. (2006). The attention-intention-effort pathway in the development of psychophysiologic insomnia: a theoretical review. *Sleep Medicine Reviews*, 10 (*4*), 215-243.

Ford, E.S., Cunningham, T.J., & Croft, J.B. (2015). Trends in self-reported sleep duration among US adults from 1985 to 2012. *Sleep, 38*(5), 829-832.

Frenda, S.J. & Fenn, K.M. (2016). Sleep less, think worse: The effect of sleep deprivation on working memory. *Journal of applied research in memory and cognition, 5,* 463-469.

Fukuda, K., Straus, S. E., Hickie, I., Sharpe, M. C., Dobbins, J. G., Komaroff, A., … Reeves, W. C. (1994). The chronic fatigue syndrome - a comprehensive approach to its defintions and study. *Annals of Internal Medicine*, *121,* 953-959.

Fuligni, A. J., & Hardway, C. (2006). Daily variation in adolescents’ sleep, activities, and psychological well-being. *Journal of Research on Adolescence, 16,* 353 – 377.

Galambos, N. L., Dalton, A. L., & Maggs, J. L. (2009). Losing sleep over it: Daily variation in sleep quantity and quality in Canadian students’ first semester of university. *Journal of Research on Adolescence, 19,* 741-761.

Gillet, N., Fouquereau, E., Forest, J., Brunault, P., & Colombat, P. (2012). The impact of organizational factors on psychological needs and their relations with well-being. *Journal of Business and Psychology*, *27*(4), 437-450.

Gradisar, M., Gardner, G., & Dohnt, H. (2011). Recent worldwide sleep patterns and problems during adolescence: A review and meta-analysis of age, region, and sleep. *Sleep Medicine*, *12*, 110-118.

Gotts, Z. M., Newton, J. L., Ellis, J. G., & Deary, V. (2016). The experience of sleep in chronic fatigue syndrome: A qualitative interview study with patients. *British Journal of Health Psychology*, *21*, 71-92.

Gross, R.T., & Borkovec, T.D. (1982). Effects of a cognitive intrusion manipulation on the sleep-onset latency of good sleepers. *Behavior Therapy*, *13*, 112-116.

Haerens, L., Aelterman, N., Vansteenkiste, M., Soenens, B., & Van Petegem, S. (2015). Do perceived autonomy-supportive and controlling teaching relate to physical education students' motivational experiences through unique pathways? Distinguishing between the bright and dark side of motivation. *Psychology of Sport and Exercise*, *16*, 26-36.

Harrison, Y., Horne, J.A. (2000). The impact of sleep deprivation on decision making: A review. *Journal of Experimental Psychology: Applied*, *6*, 236-249.

Harvey, A. G. (2000). Pre-sleep cognitive activity in insomnia: A comparison of sleep-onset insomniacs and good sleepers. *British Journal of Clinical Psychology*, *39*, 275–286.

Harvey, A.G. (2002). A cognitive model of insomnia. *Behavior Research and Therapy*, *40,* 8, 869-893.

Harvey, A.G., Gregory, A.M., & Bird, C. (2002). The role of cognitive processes in sleep disturbance: A comparison of Japanese and English university students. *Behavioural and Cognitive Psychotherapy*,*30*, 259-270.

Harvey, A.G., Murray, G., Chandler, R.A., & Soehner, A. (2011). Sleep disturbance as transdiagnostic: Consideration of neurobiological mechanisms. *Clinical Psychology Review*.

Healy, E.S., Kales, A., Monroe, L.J., Bixler, E.O., Chamberlin, K., & Soldatos, C.R. (1981). Onset of insomnia: role of life-stress events. *Psychosomatic Medicine,43,*439-451.

Howell, A. J., Digdon, N. L., & Buro, K. (2010). Mindfulness predicts sleep-related self-regulation and well-being. *Personality and Individual Differences*, *48*, 419-424.

Howell, A. J., Digdon, N. L., Buro, K., & Sheptycki, A. R. (2008). Relations among mindfulness, well-being, and sleep. *Personality and Individual Differences, 45*, 773-777.

Hull, C. L. (1943). *Principles of behavior.* New York: Appleton-Century-Crofts.

Hülsheger, U. R., Feinholdt, A., & Nübold, A. (2015). A low-dose mindfulness intervention and recovery from work: Effects on psychological detachment, sleep quality, and sleep duration. *Journal of Occupational and Organizational Psychology, 88,* 464-489.

Iber, C., Ancoli-Israel, S., Chesson, A. L., & Quan, S. F. (2007). *The AASM Manual for the Scoring of Sleep and Associated Events. Rules, Terminology and Technical Specifications.* ASSM 2007.

Jansson, M., & Linton, S.J. Psychosocial work stressors in the development and maintenance of insomnia: a prospective study. *Journal of Occupational Health Psychology, 11,* 241-248.

Jones, J. (2013, December 5-8) In U.S., 40% get less than recommended amount of sleep. Retrieved from http:// http://www.gallup.com/poll/166553/less-recommended-amount-sleep.aspx.

Kabat-Zinn, J. (1990). Full catastrophe living: using the wisdom of your body and mind to face stress, pain, and illness. New York: Delacorte Press, 1990.

Kabat-Zinn, J. (2003). Mindfulness-based interventions context: Past, present, and future. *Clinical Psychology Science and Practice*, *10*(2), 144-156.

Kahn-Greene, E. T., Killgore, D.B., Kamimori, G.H., Balkin, T.J., & Killgore, W.D.S. (2007). The effects of sleep deprivation on symptoms of psychopathology in healthy adults. *Sleep Medicine,* 2007, 215-221.

Kanen, W. J., Nazir, R., Sedky, K., & K Pradhan, B. (2015). The effects of mindfulness-based interventions on sleep disturbance: A meta-analysis. *Adolescent Psychiatry*, *5*, 105-115.

Kessler, R.C., Berglund P.A., Coulouvrat, C., Hajak, G., Roth, T., Shahly, V., Shillington, A.C., Stephenson, J.J., & Walsh, J.K. (2011). Insomnia and the performance of US workers: results from the America Insomnia Survey. *Sleep, 34*(9):1161-1171.

Killgore, W. D. S., Balkin, T. J., & Wesensten, N. J. (2006). Impaired decision-making following 49 h of sleep deprivation. Journal of Sleep Research, 15, 7–13.

Killgore, W. D. S., Killgore, D. B., Day, L. M., Li, C., Kamimori, G. H., & Balkin, T. J. (2007). The effects of 53 h of sleep deprivation on moral judgment. Sleep, 30, 345–352.

Klumpers, U.M.H., Veltman, D.J., Van Tol, M.J., Kloet, R.W., Boellaard, R., Lammerstsma, A. A., & Hoogendijk, W.J.G. (2015). Neurophysiological effects of sleep deprivation in healthy adults, a pilot study. PLoS ONE,10 (1): e0116906.

Lemola, S., Räikkönen, K., Gomez, V., Allemand, M. (2013). Optimism and self-esteem are related to sleep. Results from a large community-based sample. *International Journal of Behavioral Medicine*, *20*, 567-571.

Lau, E. Y.Y., Hui, C.H., Lam, J., & Cheung, S.F. (2017). Sleep and optimism: A longitudinal study of bidirectional causal relationship and its mediating and moderating variables in a Chinese student sample. *Chronobiology, 34*3(3), 360-372.

Lengacher, C. A., Reich, R. R., Paterson, C. L. Jim, H.S., Ramesar, S., Alinat, C.B., Budhrani, P.H., Farias, J.R., Shelton, M.M., Moscoso, M.S., Park, J.Y., & Kip, K.E. (2015). The effects of mindfulness-based stress reduction on objective and subjective sleep parameters in women with breast cancer: A randomized clinical trial. *Psycho-oncology, 24,* 424-432.

Lin, M. K., Wu, A. W., Revicki, D. A. (2002). Incorporating quality of life measures in HIV clinical trials. *HIV Clinical Trials*, 3(3):202-18.

Liu, T.Z., Xu, C., Rota, M., Cai, H., Zhang, C**.,** Shi, M.J., Yuan, R.X**.,** Weng, H., Meng, X.Y., Kwong, J.S.W., & Sun, X (2017). Sleep duration and risk of all-cause mortality: A flexible, non-linear, meta-regression of 40 prospective cohort studies. *Sleep Medicine Reviews, 32*, 28-36.

Lundh, L.-G. (2005). The role of acceptance and mindfulness in the treatment of insomnia. *Journal of Cognitive Psychotherapy*, *19*, 29–39.

Lovibond, S.H., & Lovibond, P.F. (2004). *Manual for the Depression Anxiety Stress Scales, second edition.* Psychology Foundation, Sydney.

Lund H. G., Reider, B. D., Whiting, A. B., & Prichard, J. R. (2010). Sleep patterns and predictors of disturbed sleep in a large population of college students. *Journal of Adolescent Health, 46,* 124-132. doi: 10.1016/j.jadohealth.2009.06.016.

Lundh, L.G., & Broman, J.E. (2000). Insomnia as an interaction between sleep-interfering and sleep-interpreting processes. *Journal of Psychosomatic Research, 49*(5), 299-310.

Maslow, A. H. (1943). A theory of human motivation. *Psychological Review*, *50*, 370–396.

McClelland, D. C. (1985). *Human motivation*. Glenview, IL: Scott Foresman.

McCrae, C. S., McNamara, J. P., Rowe, M. A., Dzierzewski, M. J., Dirk, J., Marsiske, M., & Craggs, J.G. (2008). Sleep and affect in older adults: using multilevel modeling to examine daily associations. *Journal of Sleep Research, 17*, 42–53.

Meier-Ewert, H.K., Ridker, P.M., Rifai, N., Regan, M.M., Price, N. J., Dinges, D.F., & Mullington, J.M. (2004). Effect of sleep loss on C-reactive protein, an inflammatory marker of cardiovascular risk. *Journal of the American College of Cardiology, 43,*(4), 678-683.

Meisinger, C., Heier, M., Löwel, H., Schneider, A., Döring, A. (2007). Sleep duration and sleep complaints and risk of myocardial infarction in middle-aged men and women from the general population: The MONICA/KORA Augsburg cohort study. *Sleep*, 30 (*9*), 1121-1127.

Minkel, J., Moreta, M., Muto, J., Htaik, O., Jones, C., Basner, M., & Dignes, D. (2014). Sleep deprivation potentiates HPA axis stress reactivity in healthy adults. *Health Psychology*, *33*(11),1430-1434.

Monk, T. H., Reynolds, C. F., Kupfer, D. J., Buysse, D. J., Coble, P. A., Hayes, A. J., Machen, M. A., Petrie, S. R. & Ritenour, A. M. (1994). The Pittsburgh Sleep Diary. *Journal of Sleep Research*, *3*, 111-120.

Morin, C.M., Rodrigue, S., & Ivers, H. (2003). Role of stress, arousal, and coping skills in primary insomnia. *Psychosomatic Medicine, 65,* 259–267.

Murray, H. A. (1938). *Explorations in personality*. New York: Oxford University Press.

Nisenbaum, R., Jones, J.F., Unger, E.R., Reyes, M., Reeves, W.C. (2003). A population-based study of the clinical course of chronic fatigue syndrome. *Health and Quality of Life Outcomes*, *1*:49.

Ohayon, M.M. (2007). Prevalence and comorbidity of sleep disorders in general population. *La Revue Du Praticien*, *57*(14), 1521–1528.

Ong, J. C., Ulmer, C.S., & Manber, R. (2012). Improving sleep with mindfulness and acceptance: A metacognitive model of insomnia. *Behaviour Research and Therapy, 50,* 651-660.

Phillips, K. D., Mock K. S., Bopp C. M., et al. (2006). Spiritual well-being, sleep disturbance, and mental and physical health status in HIV-infected individuals. *Issues in Mental Health Nursing*, 27:125–39.

Phillips, K. D., Sowell, R. L., Boyd, M., et al. (2005). Sleep quality and health-related quality of life in HIV-infected African-American women of childbearing age. *Quality of Life Resarch*,14:959–70.

Pigeon, W.R., & Perlis, M.L. (2007). Insomnia and depression: birds of a feather? *International Journal of Sleep Disorders, 1,* 82 – 91.

Pires, G.N., Bezerra, A.G., Tufik, S., & Andersen, M.L. (2016). Effects of acute sleep deprivation on state anxiety levels: a systematic review and meta-analysis. *Sleep Medicine*, *24*, 109-118.

Pillai, V., Steenburg, L.A., Ciesla, J.A., Roth, T., & Drake, C.L. (2014). A seven day actigraphy-based study of rumination and sleep disturbance among young adults with depressive symptoms. *Journal of Psychosomatic Research, 77,* 70-75

Poh, J.H., Chong, P.L.H., & Chee, M.W.L. (2016). Sleepless night, restless mind: Effects of sleep deprivation on mind wandering. *Journal of Experimental Psychology: General, 145,* 1312-1318.

Quested, E., Bosch, J., Burns, V.E., Cummings, J., Ntoumanis, N., & Duda, J.L. (2011). Basic psychological need satisfaction, cognitive appraisals, and dancers' hormonal and emotional responses. *Journal of Sport & Exercise Psychology*, *33*, 828-46.

Reeve, J., & Tseng, C.-M. (2011). Cortisol reactivity to a teacher's motivating style: the biology of being controlled versus supporting autonomy. *Motivation and Emotion, 35,* 63-74. doi: 10.1007/s11031-011-9204-2

Reibel, D., Greeson, J., Brainard, G., & Rosenzweig, S. (2001). Mindfulness-based stress reduction and health-related quality of life in a heterogeneous patient population. *General Hospital Psychiatry, 23*(4), 183-192.

Reis, H. T., Sheldon, K. M., Gable, S. L., Roscoe, J., & Ryan, R. M. (2000). Daily well-being: The role of autonomy, competence, and relatedness. *Personality and Social Psychology Bulletin*, *26*, 419-435.

Riemann, D., Spiegelharder, K., Feige, B., Volderholzer, U., Berger, M., Perlis, M., Nissen, C. (2010). The hyperarousal model of insomnia: a reivew of the concept and its evidence. *Sleep Medicine Reviews*, *14(1),* 19-31.

Russell, C., Wearden, A.J., Fairclough, G., Emsley, R.A., & Kyle, S.D. (2016). Subjective but not actigraphy-defined sleep predicts next-day fatigue in chronic fatigue syndrome: A prospective daily diary study. *Sleep, 39,* 937-944.

Ryan, R. M., Bernstein, J. H., & Brown, K. W. (2010). Weekends, work, and well-being: Psychological need satisfactions and day of the week effects on mood, vitality, and physical symptoms. *Journal of Social and Clinical Psychology*, *29*, 95-122.

Ryan, R. M., & Deci, E. L. (2008). From ego depletion to vitality: Theory and findings concerning the facilitation of energy available to the self. *Social and Personality Psychology Compass*, 2/2, 702-717.

Ryan, R. M., & Deci, E. L. (2017). *Self-Determination Theory: Basic psychological needs in motivation, development, and wellness*. New York: Guilford.

Ryan, R. M., Deci, E. L., & Vansteenkiste, M. (2016). Autonomy and autonomy disturbances in self-development and psychopathology: Research on motivation, attachment, and clinical process. In D. Cicchetti (Ed.), *Developmental Psychopathology* (3 ed.).

Ryan, R. M., & Frederick, C. M. (1997). On energy, personality, and health: Subjective vitality as a dynamic reflection of well-being. *Journal of Personality*, *65*, 529–565.

Sadeh, A. (2011). The role and validity of actigraphy in sleep medicine: An update. *Sleep Medicine Reviews, 15,* 259-267.

Schüler, J. & Kuster, M. (2011). Binge eating as a consequence of unfulfilled basic needs: The moderation role of implicit achievement motivation. *Motivation and Emotion, 35*, 89-97.

Smith, C. V. (2007). In pursuit of 'good' sex: Self-determination and sexual experience. *Journal of Social and Personal Relationships, 24*, 69-85.

Sonnentag S., Binnewies C., & Mojza E. J. (2008). "Did you have a nice evening?" A day-level study on recovery experiences, sleep, and affect. *Journal of Applied Psychology*, *93*, 674–684.

Spiegel, K., Leproult, R., & Van Cauter, E. (1999). Impact of sleep debt on metabolic and endocrine function. *Lancet, 354,* 1432-1439.

Tavernier, R., & Willoughby, T. (2014). Bidirectional associations between sleep (quality and duration) and psychosocial functioning across the university years. *Developmental Psychology, 50*(3), 674-682.

Vahtera, J., Kivimaki, M., Hublin, C., Korkeila, K., Suominen, S., Paunio, T., & Koskenvuo M. (2007). Liability to anxiety and severe life events as predictors of new-onset sleep disturbances. *Sleep, 30*, 1537-1546.

Van den Broeck, A., Vansteenkiste, M., De Witte, H., Lens, W., & Soenens, B. (2010). Capturing autonomy, relatedness and competence: Construction and validation of a work related need satisfaction scale. *Journal of Occupational and Organizational Psychology, 83*, 981-1002.

Van der Kaap-Deerder, J., Soenens, B., Mabbe, E., Dieleman, L.., Mouratidis, A., Campbell, R., & Vansteenkiste, M. (under revision). From daily need experiences to autonomy-supportive and psychologically controlling parenting via psychological availability and stress. *Manuscript under revision for Child Development.*

Van der Kaap-Deeder, J., Vansteenkiste, M., Van Petegem, S., Raes, F., & Soenens, S. (2016). On the integration of need-related autobiographical memories among late adolescents and late adults: The role of depressive symptoms and self-congruence. *European Journal of Personality.*

Vansteenkiste, M., & Ryan, R. M. (2013). On psychological growth and vulnerability: Basic psychological need satisfaction and need frustration as a unifying principle. *Journal of Psychotherapy Integration*, *23*, 263-280.

Verstuyf, J., Vansteenkiste, M., Soenens, B., Boone, L., & Mouratidis, A. (2013). Daily ups and downs in women's binge eating symptoms: The role of basic psychological needs, general self-control, and emotional eathing. Journal of Social and Clinical Psychology, 32, 335-361.

Visser, P. L., Hirsch, J. K., Brown, K.W., Ryan, R., & Moynihan, J.A. (2014). Components of Sleep Quality as Mediators of the Relation Between Mindfulness and Subjective Vitality Among Older Adults. *Mindfulness, 5(2)*, 111-222.

Vollestad, J., Nielsen, M. B., & Nielsen, G. H. (2012). Mindfulness and acceptance based interventions for anxiety disorders: A systematic review and meta-analysis. British Journal of Clinical Psychology, 51, 239-260.

Wade, A. G. (2011). The societal costs of insomnia. *Neuropsychiatric Disease and Treatment, 7*, 1-18.

Watson NF, Badr MS, Belenky G, Bliwise DL, Buxton OM, Buysse D, Dinges DF, Gangwisch J, Grandner MA, Kushida C, Malhotra RK, Martin JL, Patel SR, Quan SF, Tasali E. (2015) Recommended amount of sleep for a healthy adult: a joint consensus statement of the American Academy of Sleep Medicine and Sleep Research Society. *Sleep*, *38*(6):843–844.

Watson, D., O'Hara, M. W., Simms, L. J., Kotov, R., & Chmielewski, M. (2007). Development and validation of the Inventory of Depression and Anxiety Symptoms (IDAS). *Psychological Assessment*, *19*, 253–268.

Weinstein, N., & Ryan, R. M. (2011). A self-determination theory approach to understanding stress incursion and responses. *Stress and Health*, *27*, 4-17.

Wells, T.T., & Cruess, D.G. (2017). Effects of partial sleep deprivation on food consumption and food choice. *Psychology & Health*, *21* (1), 79-86.

Wicklow, A., & Espie, C. A. (2000). Intrusive thoughts and their relationship to actigraphic measurement of sleep: Towards a cognitive model of insomnia. *Behaviour Research and Therapy*, *38*, 679–694.

Wilder-Smith, A., Mustafa, F.B., Earnest, A., Gen, L., & Macary, P.A. (2013). Impact of partial sleep deprivation on immune markers. *Sleep Medicine*, *14*(10) 1031-4.

Winzeler, K., Voellmin, A., Schäfer, V., Meyer, A.H., Cajochen, C., Wilhelm, F.H., & Bader, K. (2014). Daily stress, presleep arousal, and sleep in healthy young women: a daily life computerized sleep diary and actigraphy study. *Sleep Medicine, 15*, 359-366.

Wood, A. M., Joseph, S., Lloyd, J., & Atkins, S. (2009). Gratitude influences sleep through the mechanism of pre-sleep cognitions. *Journal of Psychosomatic Research, 66*, 43–48.

Wu, J., Wu, H., Lu, C., Gui, L., Pengsheng, L. (2015). Self-reported sleep disturbances in HIV-infected people: a meta-analysis of prevalence and moderators. *Sleep Medicine*, 16:901–907.

Wuyts, J., De Valck, E., Vandekerckhove, M., Pattyn, N., Bulckaert, A., Berckmans, D., Haex, B., Verbraecken, J., & Cluydts, R. (2012). The influence of pre-sleep cognitive arousal on sleep onset processes. *International Journal of Psychophysiology, 83,* 8-15.

Yoo, S. S., Hu, P. T., Gujar, N., Jolesz, F. A., & Walker, M. P. (2007). A deficit in the ability to form new human memories without sleep. Nature Neuroscience, 10, 385–392.

Examining the Role of Psychological Need Satisfaction in Sleep: A Self-Determination Theory Perspective[1]

Although ample research has shown the satisfaction of the basic psychological needs for autonomy, competence, and relatedness, as defined within Self-Determination Theory, to be related to well-being, the relation with sleep-related functioning has not yet been examined. Hence, the present study explored the association between basic psychological need satisfaction and subjective measures of sleep and daytime dysfunction, as well as the explanatory role of need satisfaction in the relation between mindfulness and financial strain and these outcomes, in an adult sample (*N* = 215, 61% female; Mean age = 31). The results indicated that low psychological need satisfaction related to poor sleep quality, lower sleep quantity, and less daytime dysfunction. Finally, mindfulness and financial strain related, respectively, negatively and positively to poor sleep quality and daytime dysfunction through need satisfaction, suggesting that need satisfaction represents a critical explanatory mechanism. The role of psychological need satisfaction in the adequate regulation and satisfaction of the physiological need for sleep is discussed.

[1] Campbell, R., Vansteenkiste, M., Delesie, L., Mariman, A., Soenens, B., Tobback, E., Van der Kaap-Deeder, J., & Vogelaers, D. (2015) Examining the role of psychological need satisfaction in sleep: a self-determination theory perspective. *Personality and Individual Differences*, *77*, 199-204.

Introduction

Poor sleep impairs cognitive functioning (Curcio, Ferrara & De Gennaro, 2006) and is associated with various adverse health outcomes, such as diabetes, obesity, and cardiovascular disease (Reite, Ruddy & Nagel, 2002). Such findings highlight the necessity to identify predictors of people's sleep. Previous studies found perceived stress (Fuligni & Hardway, 2006), loneliness (Cacioppo et al., 2002), financial strain (Burgard & Ailshire, 2009), and negative affect (Stewart, Rand, Hawkens, & Stines, 2011) to relate to poor sleep, while mindfulness (Howell, Digdon, Buro, & Sheptycki, 2008) and gratitude (Wood, Joseph, Lloyd, & Atkins, 2009) related to better sleep. However, although a broad range of theoretical explanations have been proposed as to why sleep and psychological functioning are related (e.g., Riemann et al., 2010), past work examining psychological predictors of sleep has not always been grounded in an overarching psychological framework.

Self-determination theory (SDT; Ryan & Deci, 2000; Vansteenkiste, Niemiec, & Soenens, 2010) provides such a framework as it specifies principles that may help to explain why previously identified predictors of sleep relate to sleep outcomes. SDT identifies three basic psychological needs which are essential for psychological and social wellness and physical health: Autonomy involves the experience of a sense of volition and self-endorsement in one's activity; competence refers to the experience of effectiveness when interacting with one's environment; and relatedness involves the experience of reciprocal care and concern for others. Akin to drive theory (Hull, 1943) which focuses on the study of physiological needs (e.g., food, sleep), SDT conceives these psychological needs as inherent, universal, and essential for well-being. Various studies have found psychological need satisfaction to relate positively to well-being (e.g., life satisfaction), and negatively to ill-being (e.g., depressive symptoms & anxiety) (Deci & Ryan, 2000). These findings emerged across diverse life domains and both at the between-person and within-person level (Vansteenkiste et al., 2010).

More recently, a few studies began to explore the role of psychological need satisfaction in the regulation of physiological needs. For example, on days when basic psychological needs are frustrated, problems with eating regulation are more likely to occur (Verstuyf, Vansteenkiste, Soenens, Boone, & Mouratidis, 2013). In addition, psychological need satisfaction has been found to play a role in peoples' sexual experiences (Smith, 2007). However, to date no study has focused on the interplay between psychological need satisfaction and the physiological need for sleep, although indirect evidence for this association exists. For example, loneliness and attachment anxiety, which presumably involve experiences of relatedness frustration, as well as financial strain, which likely engenders experiences of autonomy frustration, have been found to relate to poorer sleep (Burgard & Ailshire, 2009; Carmichael & Reis, 2005). Further, the frustration of psychological needs is associated with stress, negative affect (Deci & Ryan 2000) and reduced vitality (Chen, Meilin, & Wenfan, 2014), all of which negatively relate to sleep outcomes (Fuligni & Hardway, 2006; Stewart et al., 2011; Visser, Hirsch, Brown, Ryan & Moynihan, 2014). Presumably, when individuals fail to get their psychological needs met, they have more negative experiences to handle which may increase pre-sleep arousal through worry and stress and in this way negatively influence sleep.

We propose that the concept of psychological need satisfaction allows for a deeper understanding of the ways in which psychological factors relate to sleep. Indeed, the effect of previously identified antecedents of these outcomes, such as mindfulness and financial strain, may be explained through their association with need satisfaction. Mindfulness involves a non-judgmental stance and receptivity for present experiences (Brown & Ryan, 2003). With regard to sleep, mindfulness would allow for a greater attunement to bodily cues of fatigue and be conducive to a greater acceptance of sleep-related functioning. Rather than trying to get a grip on or alter disturbing sleep-related thoughts and feelings, the more observing stance characteristic of mindful individuals would be conducive to a greater detachment of everyday worries that impede restful sleep. In line with this, a few previous studies found mindfulness to relate positively to sleep (Howell et al., 2008; Howell et al, 2010). Herein, we propose that need satisfaction can explain the observed salutary effects of mindfulness on sleep. Because mindful individuals display a greater awareness of ongoing events, they may be more capable of deriving a sense of need satisfaction from these events, which, in turn would predict better sleep.

In addition to mindfulness, financial strain is likely to yield a negative association with sleep through need satisfaction. Financial strain is likely to restrict freedom in daily life, cause relational conflicts, and increase self-doubts as to whether one can competently run one's life, thus leading to low need satisfaction. Although previous research found financial strain to impair sleep (Burgard & Ailshire 2009), the mechanism accounting for this association has not received attention yet.

The objective of the present cross-sectional study was to explore the relation between psychological need satisfaction and subjective measures of sleep. Two more specific aims were pursued. First, in contrast to previous research which often treated sleep as a non-differentiated category comprising diverse indicators (e.g., Howell et al., 2008), we examined whether need satisfaction would yield a similar relation to two sleep-related components, that is, sleep quantity (e.g., number of hours of sleep) and perceived sleep quality. Further, consistent with available measures in the field, such as the commonly used Pittsburgh Sleep Quality Index (PSQI) (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989), we also included various indicators of day-time dysfunction, including the Insomnia and Lassitude subscales of the Inventory of Depression and Anxiety Symptoms (IDAS) (Watson, O'Hara, Simms, Kotov, & Chmielewski, 2007), the Fatigue Severity Scale (FSS) (Rietberg, Van Wegen & Kwakkel, 2010) and the General Vitality Scale (Ryan & Frederick, 1997). Although strictly speaking such measures are not indicative of individuals' sleep as such, because they tap into feelings of exhaustion and energy during the day, they are directly related to one's sleeping pattern. We hypothesized that need satisfaction would relate negatively to poor sleep quality and daytime dysfunction. With regard to sleep quantity, we had no formal hypothesis, but rather examined the association between psychological need satisfaction and sleep quantity in an explorative fashion. In examining this hypothesis, we first tested the role of a composite score of need satisfaction and then proceeded by testing the individual and unique contributions of each of the three needs.

Second, we examined whether psychological need satisfaction would account for the relation between mindfulness and financial strain and sleep outcomes and daytime dysfunction. By proposing the same mechanism (i.e., need satisfaction) to account for the previously observed effects of diverse antecedents of sleep (i.e., mindfulness, financial strain), the concept of psychological need satisfaction may allow for a deeper integration of findings from previous studies (e.g., Burgard & Ailshire 2009; Howell et al., 2008; Howell et al, 2010).

Method

Participants and Procedure

The original sample consisted of 245 Belgian adults; however, 30 were later excluded on the basis of the exclusion criteria resulting in a final sample of 215 (61% female; Mean age = 31, SD = 14.39). Participants were recruited through the social network of three Master students of Clinical Psychology at the University of Ghent. Participants were excluded if they were less than 18 years old, had children under the age of 3, worked in shifts, used hypnotics or had a self-reported diagnosis of depression, anxiety or primary sleep disorder. All participants gave informed consent and the sample was approved by the University's Institutional Review Board.

Measures

All variables were coded so that a higher value represented a higher amount of the labeled construct. Reliabilities of all measures can be found on the diagonal in Table 1.

Basic Psychological Need Satisfaction and Need Frustration Scale (BPNSNFS). Psychological need satisfaction was assessed using the BPNSNFS (Chen et al., in press). Participants rated on a scale of 1 (*not at all true*) to 5 (*very true*) as to whether they felt their needs for autonomy (e.g., "I feel my choices express who I really am"), competence (e.g., "I feel confident that I can do things well") and relatedness (e.g., "I feel connected with people who care for me and whom I care for") were satisfied during the past month. The scale consists of 24 items in total, 8 items per need, 4 of which tap into need satisfaction and 4 which tap into need frustration. Apart from creating three separate need scores by averaging the respective means for autonomy, competence, and relatedness, we also created an overall composite score by averaging the sum of the three need variables (see also Deci et al., 2001).

Mindful Attention Awareness Scale (MAAS). Mindfulness was assessed using the MAAS (Brown & Ryan, 2003). The scale consists of 15 items which assessed the individual's awareness of his/her attention during the past month (e.g., "I found myself doing things without paying attention"). Participants rated responses on a scale of 1 (*almost always*) to 6 (*almost never*).

Financial Strain. Eight items assessed the degree to which participants worried about their financial situation over the last month (e.g., "During the last month I worried about whether I would have sufficient financial resources to provide medical care for my family and for myself") (Vansteenkiste, Lens, Dewitte, De Witte, & Deci, 2014). Participants were asked to rate each item on a 5-point Likert scale ranging from 1 (*Completely disagree*) to 5 (*Completely agree*).

Pittsburgh Sleep Quality Index (PSQI). The PSQI (Buysse et al., 1989) was used to assess sleep quality and disturbances during the past month. The PSQI consists of 19 items which generate 7 component scores: subjective poor sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of hypnotics, and daytime dysfunction. In addition, we developed two items to tap into psychological reasons for sleep disruption which followed the classic PSQI items (i.e., "Worrying" and "Somber thoughts").

Insomnia and Lassitude. *S*ymptoms of insomnia and lassitude were assessed using the corresponding subscales from the IDAS (Watson et al., 2007). Both subscales consist of 6 items and were adapted so that they focused on the last month (e.g., During the last month I felt sleepy and drowsy). Items were answered on a 5-point Likert scale ranging from 1 (*not at all*) to 5 (*very much so*).

Fatigue Severity Scale (FSS). The FSS (Rietberg et al., 2010) consists of 9 items which assessed the severity of fatigue in different situations over the past month. Participants rated responses on a scale of 1 (*completely disagree*) to 7 (*completely agree*).

General Vitality Scale. Vitality was assessed using the General Vitality Scale (Ryan & Frederick, 1997) which measured the extent to which participants felt alive and energetic over the last month (e.g., I felt very energetic; 7 items). Items were answered on a 5-point Likert scale ranging from 1 (*completely disagree*) to 5 (*completely agree*).

Statistical Analyses

To examine the structure underlying the assessed sleep parameters a second order principal component analysis with promax rotation (oblique) was performed using SPSS® 20.00 (IMB Corporation, Armonk NY, USA) , thereby inserting scale scores rather than individual items. Promax rotation was chosen because the underlying components were assumed to be correlated. Factor extraction was guided by examination of the scree plot and eigenvalues greater than 1. Component 6 of the PSQI (i.e., use of hypnotics) was omitted due to having zero variance as a consequence of the exclusion criteria.

To examine the relation between psychological need satisfaction and the retained components and to investigate whether psychological need satisfaction would account for the relation between mindfulness and financial strain and each outcome, structural equation models (SEM) were tested using Mplus7 with maximum-likelihood as estimator. In testing the role of need satisfaction, we first tested the role of a composite score of need satisfaction before examining the separate and unique contribution of each of the three needs. In the SEM analyses mindfulness, financial strain and the need for autonomy, competence and relatedness were represented by four parcels which were created through random selection of items from the corresponding scales. Parceling is considered to be an appropriate technique for creating indicators for latent variables from unidimensional scales and provides several advantages when investigating structural relations between variables (Little, Cunningham, Shahar, & Widaman, 2002). The need composite was represented by the subscales of autonomy, competence, and relatedness. Finally, the components that were retained from the second order principal component analysis were represented by the corresponding subscales.

When testing indirect effects, bootstrapping (using 1000 draws) was used to account for potential deviations from multivariate normality. Several indices were used to assess the model fit, namely the χ^2 test, the comparative fit index (CFI), the standardized root mean square residual

(SRMR), and the root mean square error of approximation (RMSEA). An acceptable fit was indicated by χ^2 /df ratio of 2 or below, CFI values of .90 or above, and SRMR and RMSEA values of around .08 or below (Hu & Bentler, 1999; Kline, 2005). In each of the models relevant background variables (i.e., age and gender) were controlled for.

Results

Preliminary Analysis

Correlations. Table 1 presents the means, standard deviations, and correlations among all the study variables. The subscales for autonomy, competence, and relatedness were highly correlated and yielded similar relations to mindfulness, financial strain and the outcomes.

Factor Structure. Examination of the scree plot indicated a three-component solution, accounting for 60.33% of the variance. The eigenvalues were: 3.93, 1.59 and 1.11. Using a promax rotation, the retained components could be clearly interpreted as indicating the three hypothesized underlying factors, that is, poor sleep quality (component 1); daytime dysfunction (component 2); and sleep quantity (component 3). The factor loadings of the scales were all satisfactory yielding a minimal loading of .66 (see Table 2).

Background variables. Next, a MANCOVA was performed to examine the effect of age, gender, and education level on the sleep outcomes. Gender and education level had no significant associations with sleep outcomes, whereas age [F (10,179) = 5.11, p <.000, η^2 = .20] yielded a significant multivariate effect. Subsequent univariate ANOVAS showed that age was negatively related with daytime dysfunction [F (1,188) = 4.19, p <.05, η^2 = .02], lassitude [F (1,188) = 19.08, p <.000, η^2 = .09] and sleep duration [F (1,188) = 4.4, p <.05, η^2 = .02].

Primary Analyses

Aim 1: Examining the Need Satisfaction – Sleep/Daytime dysfunction Relation. Prior to testing the structural models, we first inspected the measurement model, which yielded the following fit: χ^2/df = 1.4, CFI = .96, RMSEA = .04, SRMR = .05. Next, paths were allowed from the need composite to daytime dysfunction, poor sleep quality, and sleep quantity. The results of

Table 1

Means, Standard Deviations, and Correlations between the Study Variables

Measure	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Age	.13	.17*	.16*	.18*	.23**	-.26**	-.06	-.05	-.23*	.02	.12	-.14*	-.11	.02	-.33**	.06	-.02
2. Autonomy	.70	.67**	.55**	.87**	.36**	-.28**	-.24**	-.15*	.11	.10	-.17*	-.37**	-.26**	-.36**	-.46**	.51**	-.27**
3. Competence		.87	.56**	.87**	.33**	-.32**	-.33**	-.16*	.04	.17*	.06	-.33**	-.35**	-.37**	-.42**	.45**	-.31**
4. Relatedness			.88	.81**	.33**	-.25**	-.19**	-.20**	.08	.12	-.06	-.25**	-.23**	-.32**	-.28**	.29**	-.15*
5. Need composite				.89	.39**	-.33**	-.30**	-.19**	.09	.15*	-.12	-.37**	-.33**	-.41**	-.46**	.49**	-.29**
6. Mindfulness					.86	-.28**	-.22**	-.04	.10	.05	-.15*	-.48*	-.22**	-.24**	-.42**	.34**	-.31**
7. Financial strain						.91	.17*	.04	.03	-.14	.03	.23**	.17*	.09	.22**	-.27**	.30**
8. Subjective poor sleep quality							-	.46**	-.23**	-.20**	.33**	.37**	.45**	.59**	.36**	-.38**	.19**
9. Sleep latency								-	-.21**	-.27**	.24**	.21**	.45**	.42**	.14*	-.20**	.07
10. Sleep duration									-	.27**	-.11	-.19**	.03	-.26**	-.07	.19**	-.02
11. Habitual sleep efficiency										-	-.08	-.04	-.24**	-.16*	-.06	.04	-.04
12. Sleep disturbances											-	.24**	.36**	.37**	.21**	-.15*	.19**
13. Daytime dysfunction												-	.36**	.32**	.49**	-.54**	.38**
14. Negative reasons													.76	.48**	.26**	-.29**	.18**
15. Insomnia														.85	.37**	-.37**	.26**
16. Lassitude															.86	-.54**	.43**
17. Vitality																.86	-.45**
18. Fatigue severity																	.85
Mean	3.43	3.67	4.10	3.73	4.31	1.71	.99	1.20	2.51	2.67	1.11	.88	1.89	2.24	2.75	2.85	3.36
SD	.76	.76	.70	.64	.83	.87	.64	.80	.56	.60	.36	.75	.78	.94	.94	.79	1.15

Note: Internal consistencies are displayed on the diagonal.
*p <.05. **p<.01.

Table 2

Factor Loadings after Principal Component Analysis (PCA) with Promax Rotation

	Poor sleep quality	Daytime Dysfunction	Sleep Quantity
Negative reasons	.83		
Sleep disturbances	.73		
Sleep latency	.73		
Subjective poor sleep quality	.69		
Insomnia	.66		
Vitality		-.82	
Lassitude		.79	
Fatigue severity		.75	
Daytime dysfunction		.72	
Sleep duration			.86
Habitual sleep efficiency			.70
Eigenvalue	3.93	1.59	1.11
Explained Variance	35.75%	14.52%	10.06%

this model, χ^2/df = 1.9, CFI = .91, RMSEA = .06, SRMR = .06, indicated that need satisfaction related negatively to daytime dysfunction (β = -.67, p < .001) and poor sleep quality (β = -.49, p < .001) and was positively related to sleep quantity (β = .19, p < .05). Follow-up models indicated that each of the three needs, when entered separately, yielded similar relations to the outcomes as the ones observed for the composite score. When all three needs were entered simultaneously, χ^2/df =1.8, CFI = .91, RMSEA =.06, SRMR =.06, results indicated that competence related negatively to poor sleep quality (β = -.27, p < .05) and autonomy related negatively to daytime dysfunction (β = -.48, p < .001).

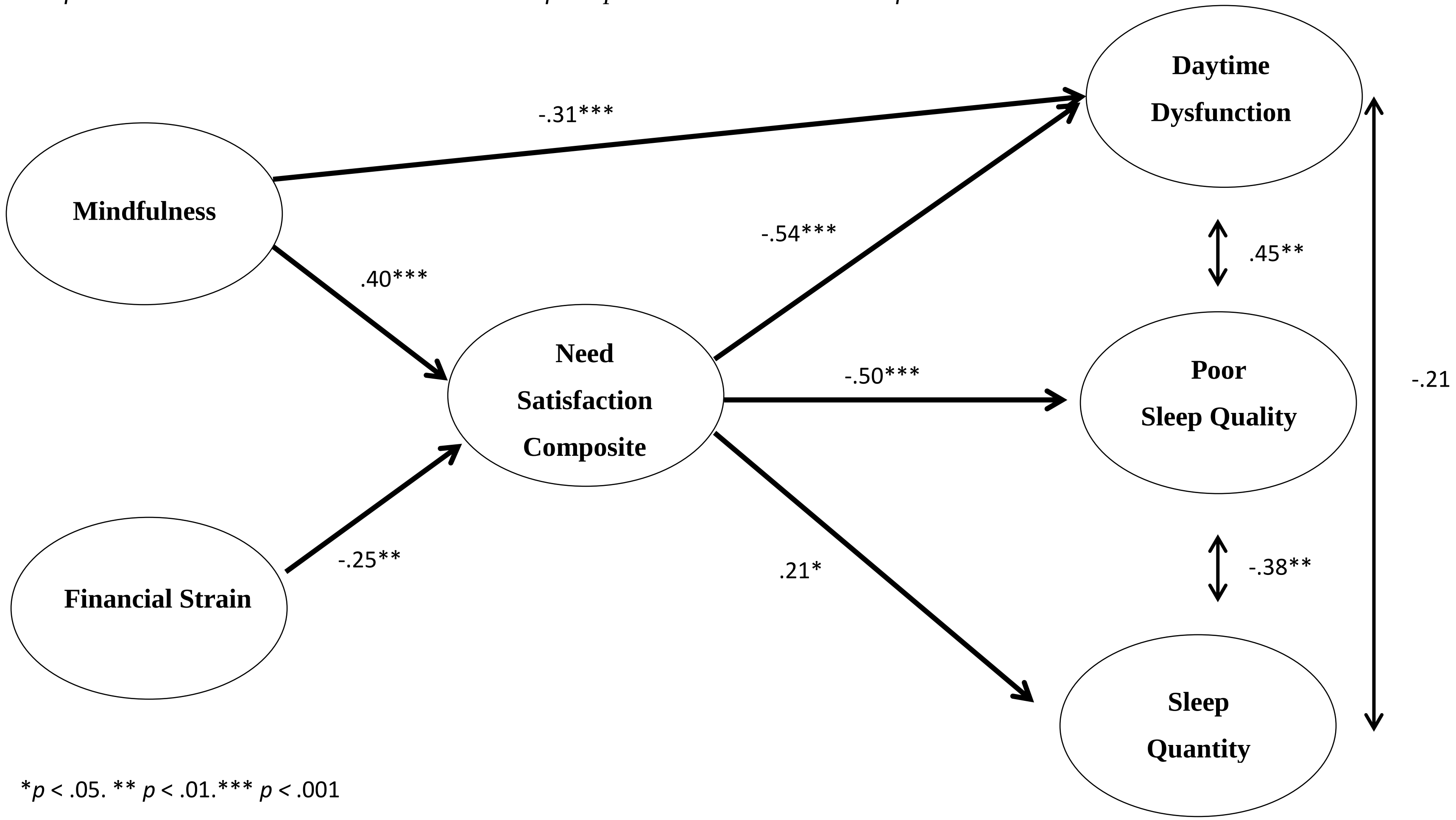
Aim 2: Testing the Proposed Integrative Model. To examine whether psychological need satisfaction would mediate the relation between mindfulness and financial strain and the outcomes, two additional SEM models were tested. First, a direct effect model was tested, thereby modeling mindfulness and financial strain as predictors of the three retained components. The results of this model, χ^2/df = 1.7, CFI = .92, RMSEA = .06, SRMR = .07, indicated that mindfulness related negatively to poor sleep quality (β = -.28, p < .01) and daytime dysfunction (β = -.54, p < .001) but was unrelated to sleep quantity (β = .18, *ns*). Financial strain related positively to daytime dysfunction (β = .19, p < .01) and was unrelated to poor sleep quality (β = .12, *ns*) and sleep quantity (β = .02, *ns*).

Next, the need composite was introduced into the model as an intervening variable between mindfulness and financial strain and the three outcomes. Paths between mindfulness and financial strain and the three outcomes were gradually added and retained if the additional path led to an improved model fit. Mindfulness continued to yield a direct negative association with daytime dysfunction leading to an improved model fit, χ^2/df = 1.7, CFI = .92, RMSEA = .06, SRMR =.07. The final integrative model is shown in Figure 1.

The indirect associations between mindfulness and poor sleep quality (β = -.20, p < .001; CI 95% [-.316; -.086]) and daytime dysfunction (β = -.22, p < .001; CI 95% [-.340; -.090]) via the need composite were significant, indicating that the need composite served as a full (in the case o

Figure 1

Mindfulness and Financial Strain as Predictors of Sleep Outcomes via Need Satisfaction



*$p < .05$. ** $p < .01$.*** $p < .001$

sleep quality) and partial (in the case of daytime dysfunction) mediator. The indirect effect of mindfulness on sleep quantity was not significant. The indirect effect of financial strain on poor sleep quality (β = .13, p < .01; CI 95% [.041; .213]) and daytime dysfunction (β = .14, p < .01; CI 95% [.043; .229]) was significant, while the indirect effect on sleep quantity was not. These results indicate that the need composite completely mediated the association between financial strain and daytime dysfunction and that financial strain had an indirect association with poor sleep quality through the need composite.

Next, when the individual needs were tested separately, the results of each need yielded a similar pattern of associations as the one found for the composite score, with the exception that none of the separate needs were related to sleep quantity. When all needs were entered simultaneously in the model to examine their unique explanatory role, the results of this model, χ^2/df = 1.6, CFI = .91, RMSEA = .06, SRMR =.07 indicated that mindfulness and financial strain related, respectively, positively and negatively to each need. Although mindfulness continued to yield a direct negative association with daytime dysfunction, it yielded an indirect association with daytime dysfunction via autonomy (β = -.15, p < .01; CI 95% [-.261; -.031]).

Discussion

To our knowledge, this study is the first to explore the interplay between the basic psychological needs for autonomy, competence, and relatedness, as defined within the Self-Determination Theory (Deci & Ryan, 2000), and the physiological need for sleep. A number of interesting findings emerged.

First, we performed a second order principal component analysis to examine the underlying structure of the battery of assessed sleep and daytime parameters. Three distinct factors representing poor sleep quality, sleep quantity, and daytime dysfunction were found. This finding is in line with previous studies which identified a 3-factor model of the PSQI as a better fit than a single-factor model in both clinical and non-clinical samples (e.g., Mariman, Vogelaers, Hanoulle, Delesie, Tobback, Pevernagie, 2012). However, in contrast to previous studies we examined additional parameters in addition to the PSQI, each of which yielded a satisfactory loading onto one of the three factors. We deemed the inclusion of a positive indicator such as vitality, which has received quite a lot of attention within positive psychology (Ryan & Fredericks, 1997), critical as to move away from a focus on fatigue by including positive indicators of energy. Overall, the separation of the PSQI into three distinct factors underscores the claim from previous studies that the global PSQI has limited usefulness as a single factor (Mariman et al., 2012). Indeed, a more heterogeneous approach involves the recognition that sleep and day-related parameters can be distinguished and that, in turn, sleep outcomes can be differentiated into more refined categories.

Next, we examined the relationship between the need satisfaction composite and the three retained components. First, psychological need satisfaction over the past month related negatively to poor sleep quality. One possible explanation for this finding is that individuals whose psychological needs are satisfied are more likely to encounter positive daily experiences and as a result, are more likely to have positive thoughts and less likely to have worries when falling asleep. This explanation is further supported by past work which found that positive pre-sleep cognitions relate to a better sleep quality, whereas negative pre-sleep cognitions relate to a poorer sleep quality (Riemann et al., 2010; Pillai, Steenburg, Ciesla, Roth & Drake, 2014; Wood et al., 2009). Second, individuals who experienced greater psychological need satisfaction also reported less daytime dysfunction. This finding is consistent with previous studies (e.g., Ryan, Bernstein, & Brown, 2010), which indicated that psychological need satisfaction is associated with more subjective energy and vitality. Lastly, the need satisfaction composite was positively related to sleep quantity, although this association was less pronounced. Similarly, this is likely because need satisfaction may lead to more positive pre-sleep thoughts which, in turn, are likely to be conducive to an earlier sleep onset and cause fewer sleep disturbances throughout the night.

Next, we tested an integrative model to examine whether psychological need satisfaction would account for the relationship between mindfulness and financial strain and sleep-related outcomes. Extending past work which found mindfulness and financial strain to relate to sleep outcomes (Howell et al., 2008; Howell et al, 2010; Burgard & Ailshire, 2009), the need satisfaction composite accounted for the relation between both predictors and poor sleep quality as well as daytime dysfunction. Presumably, the open awareness characteristic of mindfulness likely facilitates attention to one's internal world and psychological functioning and in doing so, increases the likelihood that one will act in ways that fulfill basic psychological needs, which in turn enables better sleep outcomes. In addition, when encountering problems with falling asleep, mindful individuals may be more able to accept sleep-interfering thoughts rather than resist them, which would be further conducive to their sleep. In contrast, financial strain is likely to restrict the freedom to act in accordance with one's desires, undermine one's feeling of competence in providing for oneself and one's family and increase interpersonal conflict, therefore thwarting psychological needs, which in turn may impair sleep.

Although the present findings provide support for the need satisfaction composite as a critical explanatory mechanism in the relation between mindfulness, financial strain and sleep quality and daytime dysfunction, it should be noted that these effects were weakened when the unique contribution of each need was considered. Although both mindfulness and financial strain related to each of the three needs, the pattern of unique associations between the three needs and the outcomes was not very systematic. Given the lack of uniformity and the fact that this is the first study to shed light on this issue, it seems too early to speculate as to why a particular need might play a more prominent role for some outcomes and not for others. More research in both convenience and clinical samples is needed.

Limitations

A number of limitations warrant caution when interpreting the current findings. First, the cross-sectional design prevents us from drawing conclusions about the direction of effects. For example, perceived poor sleep quality may not only follow from low psychological need satisfaction but may also preclude future need satisfaction, an issue that can be pursued in future diary and experimental research. Second, although the relation between need satisfaction and sleep may be accounted for by stress and sleep-interfering thoughts, these specific mechanisms were not measured and, hence, await further testing. Third, all assessed measures were self-reported. For some measures (e.g., sleep duration) self-reports may have undermined validity due to its reliance on adequate recall, an issue that could be overcome by using objective measures to assess sleep parameters. Lastly, given we used a convenience sample, the proposed model needs to be replicated in a clinical sample of sleep disordered patients to see whether these associations are generalizable.

Conclusion

Using a differentiated approach, the present study revealed that the satisfaction of the psychological needs for autonomy, competence, and relatedness related negatively to poor sleep quality and daytime dysfunction, while being positively related to sleep quantity. Further, need satisfaction was found to account for the relationship between mindfulness and financial strain and poor sleep quality and daytime dysfunction. Overall, these findings suggest that psychological need satisfaction may play a critical role in how we appraise the quality of our sleep and how we function throughout the day.

References

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology,84*, 822-48.

Burgard, S.A. & Ailshire, J. A. (2009). Putting work to bed: Stressful experiences on the job and sleep quality. *Journal of Health and Social Behaviour, 50*, 476-492.

Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R. & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index – a new instrument for psychiatric practice and research. *Psychiatry Research, 28,* 193-213.

Cacioppo, J.T., Hawkley, L. C., Bernston, G. C., Ernst, J. M., Gibbs, A.C., Stickgold, R., & Hobson, J. A. (2002). Do lonely days invade the night? Potential social modulation of sleep efficiency. *Psychological Science, 13*, 384-387.

Carmichael, C. L., & Reis, H. T. (2005). Attachment, sleep quality and depressed affect. *Health Psychology, 24,* 526-531.

Chen, B., Vansteenkiste, M., Beyers, W., Boone, L., Deci, E. L., Duriez, B. Lens, W., Matos, L., Mouratidis, A., Ryan, R. M., Sheldon, K. M., Soenens, B., Van Petegem, S., Van der Kaap-Deeder, J., & Verstuyf, J (in press). Basic psychological need satisfaction, need frustration, and need strength across four cultures. *Motivation and Emotion.*

Chen, Y., Yao, M, & Yan, W. (2014). Materialism and well-being among Chinese college students: The mediating role of basic psychological need satisfaction. *Journal of Health Psychology, 19(10)*, 1232-1240.

Curcio, G., Ferrara, M., De Gennaro, L. (2006). Sleep loss, learning capacity and academic performance. *Sleep Medicine Reviews, 10(5),* 323 – 37.

Deci, E. L. & Ryan, R. M. (2000). The “what” and “why” of goal pursuits: Human needs and the self-determination of behavior. *Psychological Enquiry*, *11*, 227–268.

Deci, E. L., Ryan, R. M., Gagné, M., Leone, D. R., Usunov, J., & Kornazheva, B. P. (2001).

Need satisfaction, motivation, and well-being in the work organizations of a former Eastern Bloc country: A cross-cultural study of self-determination. *Personality and Social Psychology Bulletin, 27*, 930–942.

Fuligni, A.J. & Hardway, C. (2006). Daily variation in adolescents' sleep activities and psychological well-being. *Journal of Research on Adolescence*, *16*, 353 – 378.

Howell, A. J., Digdon, N. L., & Buro, K. (2010). Mindfulness predicts sleep-related self-regulation and well-being. *Personality and Individual Differences*, *48*, 419-424.

Howell, A. J., Digdon, N. L., Buro, K., & Sheptycki, A. R. (2008). Relations among mindfulness, well-being, and sleep. *Personality and Individual Differences, 45*, 773-777.

Hu, L., Bentler, P.M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6*, 1-55.

Hull, C. L. (1943). *Principles of behavior*. New York: Appleton-Century-Crofts.Kline, R. B. (2005). *Principles and practice of structural equation modeling*. New York: Guilford Press.

Little, T. D., Cunningham, W. A., Shahar, G., & Widaman, K. F. (2002). To parcel or not to parcel: Exploring the question, weighing the merits. *Structural Equation Modeling, 9*, 151-173.

Mariman, A., Vogelaers, D., Hanoulle, I., Delesie, L., Tobback, E., Pevernagie, D. (2012). Validation of the three-factor model of the PSQI in a large sample of chronic fatigue syndrome (CFS) patients. *Journal of Psychosomatic Research*, *72*, 111-113.

Pillai, V., Steenburg, L.A., Ciesla, J.A., Roth, T., & Drake, C.L. (2014). A seven day actigraphy-based study of rumination and sleep disturbance among young adults with depressive symptoms. *Journal of Psychosomatic Research, 77*, 70-75

Reite, M., Ruddy, J., & Nagel, K. (2002). *Concise guide to evaluation and management of sleep disorders* (3rd ed.). Washington, D.C: American Psychiatric Pub.

Riemann, D., Spiegelharder, K., Feige, B., Volderholzer, U., Berger, M., Perlis, M., Nissen, C. (2010). The hyperarousal model of insomnia: a reivew of the concept and its evidence. *Sleep Medicine Reviews, 14(1),* 19-31. Rietberg, M., Van Wegen, E., & Kwakkel, G. (2010). Measuring fatigue in patients with multiple sclerosis: reproducibility, responsiveness and concurrent validity of three Dutch self-report questionnaires. *Disability and Rehabilitation, 32*,1870-6.

Ryan, R. M., & Frederick, C. M. (1997). On energy, personality, and health: Subjective vitality as a dynamic reflection of well-being. *Journal of Personality*, *65,* 529–565.

Ryan, R. M., Bernstein, J. H., & Brown, K. W. (2010). Weekends, work, and well-being: psychological need satisfactions and day of the week effects on mood, vitality, and physical symptoms. *Journal of Social and Clinical Psychology*, 29, 95-122.

Smith, C. V. (2007). In pursuit of ‘good’ sex: Self-determination and sexual experience. *Journal of Social and Personal Relationships, 24,* 69-85.

Stewart, J. c., Rand, K. L., Hawkens, M. AA. W., & Stines, J. A. (2011). Associations of the shared and unique aspects of positive and negative emotional factors with sleep quality. *Personality and Individual Differences*, *50,*609 – 614.

Vansteenkiste M., Niemiec, C. P., & Soenens, B. (2010). The development of the five mini-theories of self-determination theory: A historical overview, emerging trends and future directions. In T. Urdan & S. Karabenick (Eds.), *Advances in motivation and achievement, vol. 16 The decade ahead* (pp. 105 – 166). UK: Emerald Publishing. Doi: 10.1108/S0749-7423(2010)000016A007

Vansteenkiste, M., Lens, W., Dewitte, S., De Witte, H, & Deci, E. L. (2004). The “why” and “why not” of job search behavior: Their relation to searching, unemployment experience and well-being. *European Journal of Social Psychology, 34,* 345-363.

Verstuyf, J., Vansteenkiste, M., Soenens, B., Boone, L., & Mouratidis, A. (2013). Daily ups and downs in women's binge eating symptoms: The role of basic psychological needs, general self-control, and emotional eating. *Journal of Social & Clinical Psychology*, 32, 335-361.

Visser, P. L., Hirsch, J. K., Brown, K.W., Ryan, R., & Moynihan, J.A. (2014). Components of Sleep Quality as Mediators of the Relation Between Mindfulness and Subjective Vitality Among Older Adults. *Mindfulness, 5(2),* 111-222.

Watson, D., O'Hara, M. W., Simms, L. J., Kotov, R. & Chmielewski, M. (2007). Development and validation of the Inventory of Depression and Anxiety Symptoms (IDAS). *Psychological Assessment, 19*, 253-268.

Wood, A. M., Joseph, S., Lloyd, J., & Atkins, S. (2009). Gratitude influences sleep through the mechanism of pre-sleep cognitions. *Journal of Psychosomatic Research, 66*, 43–48.

University Students' Sleep during an Exam Period: The Role of Basic Psychological Needs and Stress[1]

During exam periods university students are at risk for poor sleep. To understand variability in this vulnerability for poor sleep, the role of the satisfaction and frustration of the basic psychological needs for autonomy, competence, and relatedness was examined by assessing university students (*N* = 121; 78% female; *M*age = 21.69, SD = 1.39, Range = 19-25) before, during, and after an exam period. Need-based and sleep-related functioning deteriorated during the exam period, and then improved after the exam period. As need frustration increased (i.e., from pre-exam to exam period) sleep and daytime functioning deteriorated, while subsequent decreases in need frustration (i.e., from exam to the post-exam period) were accompanied by improvements in sleep and daytime functioning. The reverse pattern was observed for need satisfaction. These correlated changes in need experiences and sleep-related outcomes were largely accounted for by changes in stress, suggesting that stress is a critical explanatory mechanism.

[1] Campbell, R., Vansteenkiste, M., Beyers, W., & Soenens, B. (2017). University students' sleep during an exam period: The role of basic psychological needs and stress. *Manuscript submitted for publication.*

Introduction

Emerging adulthood is conceptualized as a distinct developmental period during which youth often move away from home, begin higher education and parental supervision typically lessens (Arnett, 2000), bringing with it new and unique challenges to sleep. Relative to adolescents, emerging adults who enter university generally have more freedom when setting bedtimes and more flexible class start times (Urner, Tornic, Bloch, 2009; Zimmerman, 2011), both of which need to be managed in combination with increased academic demands, likely impacting on sleep. Sleep difficulties are prevalent among university students, with average estimates of sleep duration in particular not reaching recommended levels (e.g., Doane, Gress-Smith, Breitenstein, 2015; Lund, Reider, Whiting & Prichard, 2010). Moreover, sleep has been shown to deteriorate during times when university students experience increased academic demands and stress, such as examination periods (Ahrberg, Dresler, Nierdermaier, Stieger, & Genzel, 2012; Zunhammer, Eichhammer, & Busch, 2014). Such sleep disturbances warrant attention, given that poor sleep is associated with poor academic functioning (Taylor, Vatthauer, Bramoweth, & Ruggero, 2013). More importantly, poor sleep has been put forward as a transdiagnostic risk factor for the development of psychopathology (Harvey, 2008).

Previous research indicates that quality and quantity of sleep varies considerably among university students on a daily, monthly, and yearly basis (e.g., Galambos, Dalton, & Maggs, 2009; Galambos, Howard & Maggs 2010; Galambos, Vargas Lascano, Howard & Maggs, 2013). However, only a small number of studies have examined factors that contribute to such within-person variation. The present short-term longitudinal study sought to examine the covariation between changes in the satisfaction and frustration of the basic psychological needs for autonomy, competence and relatedness, as conceived within Self-Determination Theory (SDT; Deci & Ryan, 2000), and changes in university students' sleep-related functioning on a monthly basis. In addition, by assessing participants' experienced stress before, during and after exposure to a common and potentially stressful event (i.e., an exam period) we also aimed to examine the intervening role of changes of stress in these dynamic associations.

Self-Determination Theory: Basic Psychological Needs

SDT is a macro-theory of human motivation that states that all human beings dispose of a set of inherent psychological needs (i.e., the need for autonomy, competence and relatedness) that when satisfied promote adaptive functioning (e.g. growth and well-being) and when frustrated yield negative effects (e.g., ill-being). Autonomy involves experiencing a sense of volition and self-endorsement in one's behavior. Competence involves feeling capable and effective in achieving desired outcomes. Relatedness involves feeling close and connected with important others. When needs are satisfied, people experience the freedom to be themselves (autonomy satisfaction), feel capable in dealing with daily tasks and challenges (competence satisfaction), and experience warmth and trust in their relationships (relatedness satisfaction). Conversely, need frustration manifests in pressure to think, act or feel a certain way (autonomy frustration), feelings of failure and inadequacy (competence frustration) and loneliness and alienation (relatedness frustration) (Deci & Ryan, 2000; Vansteenkiste & Ryan, 2013).

In accordance with the claim that these needs represent critical nutrients for wellness, satisfaction of these psychological needs has been found to relate to higher vitality, self-esteem and life satisfaction, whereas the frustration of these needs relates to emotional and physical exhaustion (for an overview see Deci & Ryan, 2000; Vansteenkiste & Ryan, 2013). Such findings emerged among individuals from diverse cultural backgrounds and even among those who report a low desire for or valuation of the satisfaction of these needs (Chen et al., 2015). More recently, studies increasingly indicate that need satisfaction is especially predictive of positive outcomes, whereas need frustration is especially predictive of negative outcomes (e.g., Bartholomew, Ntoumanis, Ryan, & Thøgersen-Ntoumani, 2011; Verstuyf, Vansteenkiste, Soenens, Boone, & Mouratidis 2013).

On the basis of SDT, it can be predicted that these basic psychological needs are not only relevant to psychological well-being but also to physical outcomes such as sleep (Deci & Ryan, 2000). For example, previous research indicates that psychological need frustration engenders both stress (e.g., Reeve & Tseng, 2011) and ruminative thinking (Van der Kaap-Deeder et al., 2016), both of which to relate to poor sleep (e.g., Guastella & Moulds, 2007; Lund et al., 2010). However, to date, the relation between basic psychological needs and quality and quantity of sleep has received little empirical attention. One previous study relying on a between-person design indicated that adults who experienced higher psychological need satisfaction over the past month, also reported better sleep quality, more adaptive daytime functioning as indexed by higher feelings of vitality and lower fatigue, and somewhat longer sleep duration (Campbell et al., 2015). However, to the best of our knowledge no studies have examined more dynamic within-person associations between changes in the satisfaction and frustration of basic psychological needs and changes in sleep-related outcomes. A first central aim of the present study was to examine such within-person associations during an exam period because students are likely to show more substantial change and variability in quality and quantity of sleep during exams.

Previous research provides some indirect evidence for the existence of such within-person associations among university students. For instance, expecting to take a test the next day, which may lead to pressured studying and performance anxiety, thereby giving rise to experiences of autonomy and competence frustration, has been shown to relate to shorter daily sleep duration (Galambos et al., 2009). A few studies also indicate that socializing with friends and social support, both of which presumably engender relatedness satisfaction, relate to within-person fluctuations in quality and quantity of sleep. For example, socializing with friends has been shown to relate to higher daily and monthly quality of sleep (Galambos et al., 2009; Galambos et al., 2010), whereas social support related to higher yearly quantity of sleep (Galambos et al., 2013). Moreover, a diary study showed increases in daily social connection to be associated with higher sleep quantity, but only among students high on trait loneliness (Sladek & Doane, 2015). Finally, diary studies have also demonstrated a link between daily need satisfaction and more daily positive affect and less negative affect (e.g., Ryan, Bernstein, & Brown, 2010), both of which have previously been linked to within-person fluctuations in university students' quality and quantity of sleep (Galambos et al., 2009; Galambos et al., 2010). No study to date, however, has used direct and SDT-based measures of the psychological needs to examine within-person associations of psychological need satisfaction and frustration with sleep among university students.

The Role of Stress

A second important aim of this study involved examining the intervening role of stress in the relation between psychological need experiences and university students' sleep-related functioning. Researchers have theorized that stressful events evoke powerful feelings of threat and arousal which likely obstruct restful sleep at night (Dahl & Lewin, 2002). Accordingly, various studies indicate that perceived stress is detrimental to sleep among university students. For example, a cross-sectional study in a large sample of university students found perceived stress to be associated with poorer sleep quality (Lund et al., 2010). Further, a study of first year university students involving seven assessments throughout the year found sleep quality and sleep quantity to be lower in months when stress was higher (Galambos, et al., 2010). Similarly, another longitudinal study found sleep and stress to co-vary across years with students reporting longer sleep duration and fewer sleep disturbances during less stressful years (Galambos, et al., 2013). Further, increases in perceived stress during potentially stressful periods, such as exam periods, have been shown to be predictive of diminished sleep quality (Zunhammer et al., 2014).

In the present study we propose that lower psychological need satisfaction and increased psychological need frustration may help to explain why some students experience more stress and as a consequence more sleep difficulties during exam periods. Assuming this hypothesis to be true, students' experiences of psychological need frustration should vary as a function of their exposure to an exam period. That is, we should observe that need frustration, subjective stress, and sleep difficulties fluctuate in tandem as individuals are exposed to and emerge from an exam period. Exam periods not only involve increased stress and more sleep difficulties (e.g., Zunhammer et al., 2014), but likely also lower need satisfaction and greater experiences of need frustration. Exams are a time when students are likely to feel restricted in their freedom, have doubts about their capabilities to master the study material and achieve desired grades, and have more limited social interactions due to high academic pressure and demands. We propose that lower need satisfaction and increased need frustration during exam periods may co-vary with symptoms of stress such as tension, over-arousal or inability to relax, which in turn would likely impair daytime functioning and impede restful sleep at night.

In line with this reasoning a few previous studies have provided direct evidence for the association between psychological need experiences and indicators of stress (see Weinstein & Ryan, 2011 for an overview). For example, in a study of dancers higher psychological need satisfaction was associated with lower stress response during performance conditions (Quested et al., 2011). Further, psychological need frustration resulting from exposure to a controlling teaching style has been shown to be associated with elevations in stress (Reeve & Tseng, 2011). However, the intervening role of stress in the relation between psychological need experiences and sleep has not yet been examined.

The Present Research

In the present short-term longitudinal study we assessed university students' psychological need experiences and their quality and quantity of sleep before, during and after an exam period. To be consistent with the Pittsburgh Sleep Quality Index (PSQI; Buysse, Reynolds, Monk, Berman, & Kupfer, 1989), one of the most commonly used measures to assess sleep, we also included various indicators of daytime dysfunction (i.e., the General Vitality Scale, Ryan & Frederick, 1997, and the lassitude subscale of the Inventory of Depression and Anxiety Symptoms (IDAS), Watson, O'Hara, Simms, Kotov, & Chmielewski, 2007), which tapped into feelings of energy and exhaustion. Although such measures do not directly assess sleep, we deemed their inclusion important given their obvious relation with sleep.

First, we examined how psychological need experiences, sleep and daytime functioning unfolded as participants went through an exam period, thereby expecting negative outcomes (i.e., need frustration, stress, and poor sleep quality) to increase from the pre- to the exam period and to decrease from the exam to the post-exam period, while the reverse pattern was expected for positive outcomes (i.e., need satisfaction and sleep quantity; Hypothesis 1). Second, apart from inspecting these mean-level changes we also examined the covariation between changes in need experiences and changes in the sleep and day-time outcomes across time, thereby examining whether they increased and decreased in tandem. We expected increases in need frustration and decreases in need satisfaction to go along with increases in negative outcomes and decreases in positive outcomes (Hypothesis 2). Finally, we considered the intervening role of stress in the relation between psychological need experiences and the outcomes. That is, we tested an integrated model that posits within-person changes in stress as an intervening variable in the relation between changes in need satisfaction and need frustration and changes in the sleep and daytime outcomes (Hypothesis 3).

Method

Participants and Procedure

All participants were recruited at the Ghent University through an electronic learning platform for students. Upon recruitment all participants were informed that they would be required to complete an online questionnaire at three different time points; once in the month of May, once in the month of June during an examination period and once in the month of July. The link to the questionnaire was sent at the beginning of each month and participants were asked to complete the questionnaire on a Sunday or at the very latest a Monday morning with respect to the preceding week. In contrast to the first and third assessments, during the second assessment participants were given specific instructions to complete the questionnaire at the end of the week in which they had the highest number of exams. The average number of exams during the exam period was 5.84; *SD* 2.39; Range 2-13. The average number of days between assessments was 24.34; *SD* 6.92 between the 1st and 2nd and 38.01; *SD* = 7.31 between the 2nd and 3rd. Reminders were sent throughout the duration of the study to stimulate the participants to fill in the questionnaire if they had not previously done so. All participants were assigned a unique code to ensure confidentiality and that the data from each participant could be matched across the three waves. The first page of the online questionnaire stipulated the voluntary and confidential nature of the study. All participants were required to read this page before providing online informed consent, which was received from all participants. The study was conducted according to the guidelines of the ethical committee of the Faculty of Psychology and Pedagogic Sciences at the Ghent University. Given that all participants were over 18 years of age and filled in an online informed consent form in which they were informed that they could withdraw from the study at any point and that their anonymity was guaranteed, ethical approval was not needed.

The final sample consisted of 121 Belgian emerging adults (78% female) with a mean age of 21.69 years (ranging from 19 to 25; *SD* = 1.39). Eighty-six percent of the participants were university students and the remaining 14% were following a non-university form of higher education. Of the 121 respondents, 87 (72%) participated in all three waves. Sample attrition was examined in two steps. First, individuals who participated in all three waves were dummy coded as 1 (retention), and individuals who participated in only one or two waves were coded as 0 (drop-out). Logistic regression analysis was then performed by entering demographic variables (e.g., age and gender) in Step 1 and all Time 1 study variables in Step 2 to predict sample attrition. Model chi-square for Step 1 $\chi 2(2) = 3.537$, $p > .05$ and Step 2 $\chi 2(14) = 11.314$, $p > .05$ was not significant, indicating that the demographic and study variables did not contribute significantly to the prediction of dropout. Further, Little's MCAR was non-significant (normed χ^2 of .99), indicating that data were likely to be missing at random. As a result, Full Information Maximum Likelihood (FIML) was used to handle missing data in SEM (Little & Rubin, 1987).

Measures

Basic Psychological Needs. The satisfaction and frustration of the needs for autonomy, competence, and relatedness was assessed using the Basic Psychological Need Satisfaction and Need Frustration Scale (BPNSNFS; Chen et al., 2015). The scale consists of 24 items, 8 items per need, 4 of which tap into need satisfaction and 4 of which tap into need frustration. Participants rated all items on a scale of 1 (*not at all true)* to 5 (*very true)* with respect to the preceding week. A need satisfaction and need frustration composite score was created by averaging the sum of the 12 items assessing need satisfaction and the 12 items assessing need frustration. Cronbach's alpha for the need satisfaction and need frustration composite scores ranged between .84 - .86 and between .88 - .90, respectively.

Stress. Symptoms of stress were assessed using the stress subscale from the short-form version of the Depression Anxiety and Stress Scale (DASS; Lovibond & Lovibond, 2004). The stress subscale consists of 7 items which measure the prevalence of symptoms of stress during the past week (e.g., "I tended to over-react to situations"). Participants rated items on a 4-point Likert scale, ranging from 0 (*did not apply to them*) to 3 (*applied very much, or most of the time*). Cronbach's alpha ranged between .89 and .92.

Sleep and Day-Related Measures. Several measures were included to assess quality and quantity of sleep and daytime functioning. A principal component analysis (PCA; See preliminary analysis) was performed to examine the structure underlying the assessed sleep parameters. Below the indicators of the three retained components are described.

Poor sleep quality. Poor sleep quality during the previous week was assessed using six indicators. These were the subjective poor sleep quality, sleep latency, sleep disturbances and use of sleep medication component scores from the PSQI (Buysse et al., 1989), the insomnia subscale from the IDAS (Watson et al., 2007; e.g., "During the past week I woke up frequently throughout the night"; 6 items), and a composite of 2 items assessing sleep disturbing cognitions (Campbell et al., 2015; e.g., "Worrying" and "Somber thoughts; 2 items). The insomnia items (α range = .82 - .89) were rated on a 5-point Likert scale ranging from 1 (*not at all)* to 5 (*very much so*) and the sleep disturbing cognitions (α range = .78 - .82) were rated on an event-frequency scale ranging from 0 (*Not experienced during the past week*) to 3 (*Experienced three or more times*).

Sleep quantity. The previous week's sleep quantity was assessed using the sleep duration and habitual sleep efficiency component scores from the PSQI (Buysse et al., 1989). Both scores were reversed such that a higher score was representative of longer sleep duration and higher sleep efficiency.

Daytime dysfunction. Daytime dysfunction was assessed using the daytime dysfunction component score from the PSQI (Buysse et al., 1989), a measure of subjective vitality (General Vitality Scale; Ryan & Frederick, 1997; e.g., "I felt energized"; 7 items), and the lassitude subscale from the IDAS (Watson et al., 2007; e.g., "During the past week I felt sleepy and drowsy"; 6 items).

The vitality (α range = .84 - .86) and lassitude items (α range = .78 - .82) were rated on a 5-point Likert scale ranging from 1 (*completely disagree* or *not at all)* to 5 (*completely agree* or *very much so).*

Statistical Analysis

To examine the relation between intra-individual changes in need experiences and sleep and daytime parameters across measurement moments latent change models (LCMs) were tested using Mplus7 with Maximum Likelihood as estimator. LCMs estimate within-person change across 2 adjacent waves, using latent variables for intercept (i.e., level) and slope (i.e., change over time) (Beyers & Goossens, 2008). Variance in the slope indicates between-person differences in within-person change over time. Using LCMs we estimated in separate models change from the pre-exam period to the exam period and from the exam period to the post-exam period. The decision to model change across the three waves in two separate models is informed by the fact that the nature of the transition from Wave 1 to Wave 2 (i.e., transitioning into an exam period) is qualitatively different from the nature of the transition from Wave 2 to Wave 3 (i.e., transitioning out of the exam period). Given that both transitions are qualitatively different it seemed less appropriate to model change across the 3 waves using one overall parameter of change.

Each latent change model consisted of a longitudinal measurement model defining the latent variables (i.e., need satisfaction, need frustration, sleep quality, sleep quantity, daytime dysfunction and stress) at each time point by their respective indicators and a structural model which defined latent level and change factors for each latent variable and further specified how these levels and changes were interrelated (Hertzog, Dixon, Hultsch, & MacDonald, 2003). Further, co-variances among the residuals of the same indicators over time were specified (Sörbom, 1975) and background variables (i.e., age and gender) were controlled for in all models. Model fit was evaluated using the Comparative Fit Index (CFI); the Root Squared Error of Approximation (RMSEA) and the Standardized Root Means Square Residual (SRMR). An acceptable fit was indicated by CFI values of .90 or above, and RMSEA and SRMR values of around .08 or below (Hu & Bentler, 1999; Kline, 2005).

In the longitudinal measurement model, each latent variable was represented by two parcels. Parcels were created by combining stronger loading items with weaker loading items from each scale (Little, Cunningham, Shahar, & Widaman, 2002). Need frustration and need satisfaction were indicated by the same two six-item parcels at each time point whereas stress was indicated by one three-item and one four-item parcel. Indicators for the latent constructs of sleep quality, sleep quantity and daytime dysfunction were determined from a second order PCA (see preliminary analyses) performed at all three waves, thereby using scale scores rather than items as indicators and averaging the standardized factor loadings across the three waves. As more than two indicators were retained for sleep quality and daytime dysfunction, stronger and weaker loading factor scores were combined to create two parcels, whereas sleep quantity was represented by the two indicators determined in the PCA.

Results

Preliminary Analyses

Factor Structure. The structure underlying the battery of sleep parameters assessed at each time point was examined using PCA with promax rotation. Promax rotation was chosen because the underlying sleep and daytime parameters were assumed to be correlated. At each wave PCA resulted in 3 components with eigenvalues greater than 1, which combined explained 63.31%, 63.29% and 65.34% of the variance at Waves 1 to 3, respectively. Inspection of the scree plot also indicated a three factor solution at each wave. Standardized loadings averaged across the three waves varied between .41 and .87, with an average of .62. The retained components were similar to those found in Campbell et al. (2015) and clearly represented poor sleep quality (including sleep latency, insomnia symptoms, sleep disturbing cognitions, sleep quality, use of sleep medication and sleep disturbances), sleep quantity (including habitual sleep efficiency and sleep duration) and daytime dysfunction (including daytime dysfunction, lassitude, and vitality).

Descriptive Statistics and Correlations. Composite scores were created for sleep quantity, poor sleep quality and daytime dysfunction by computing the mean of the corresponding indicators determined in the PCA. Correlations between all study variables across the three measurement waves are displayed in Table 1. All study variables were related in the expected directions except for sleep quantity which was unrelated to need satisfaction and need frustration at T1 and unrelated to need satisfaction at T2. All rank-order stability coefficients were significant ranging from .26 to .67 apart from two exceptions, namely sleep quantity at T2 and T3 and daytime dysfunction at T2 and T3.

For descriptive purposes the seven components of the PSQI were summed to compute a Global PSQI score at each time point. A cut-off of >5 is used to distinguish between “good sleepers” and “poor sleepers”, with higher scores representing poorer global sleep quality. (Buysse et al., 1989). A repeated measures ANOVA revealed a significant quadratic trend in Global PSQI scores across the three time points, $F(1,86) = 44.31$, $p <.01$, $\eta^2 = .34$. Post-hoc tests using the Bonferonni correction revealed that Global PSQI scores were significantly higher ($p < .01$) at T2 ($M = 5.70$, SD = 2.45) than at T1 ($M = 4.13$, SD = 2.70) and T3 ($M = 3.92$, SD = 2.35), whereas differences between T1 and T3 were not significant. The percentage of individuals with a Global PSQI score >5 displayed a similar pattern and was highest at T2 = 38% relative to T1= 30.1% and T3 = 17%.

Background Variables. The relation between background characteristics (i.e., age and gender) and the study variables was assessed using a repeated measures MANCOVA, with measurement time as a within-subjects variable, gender as a between-subjects variable, age as a covariate and all study variables as dependent variables. Time had a significant multivariate main effect, $F(6,50) = 9.21$, $p < .01$, $\eta^2 = .71$, which will be discussed in greater detail in the primary analyses. Neither the multivariate age main effect, $F(6, 50) = 2.17$, *ns*, nor the Age X Time interaction, $F(12,44) = 1.47$, *ns*, was significant. A significant multivariate main effect of gender was found, $F(6,50) = 2.92$, $p < .05$, $\eta^2 = .26$, with males reporting significantly lower sleep quantity than females, $F(1, 55) = 4.66$, $p < .05$, $M_{men} = 3.37$, $M_{women} = 3.68$. The Gender X Time interaction, $F(12,44) = 1.39$, *ns*, was not significant, indicating that the reported changes across time were similar for males and females.

Table 1

Correlations between the study variables across the three waves

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Need frustration T1	-																	
2. Need satisfaction T1	-.68**	-																
3. Stress T1	.58**	-.39**	-															
4. Sleep quantity T1	-.35**	.25*	-.33**	-														
5. Poor sleep quality T1	.40**	-.33**	.57**	-.44**	-													
6. Daytime dysfunction T1	.63**	-.63**	.51**	-.32**	.42**	-												
7. Need frustration T2	.67**	-.47**	.48**	-.27**	.36**	.44**	-											
8. Need satisfaction T2	-.49**	.56**	-.36**	.27*	-.29**	-.45**	-.76**	-										
9. Stress T2	.45**	-.32**	.61**	-.27**	.37**	.38**	.69**	-.53**	-									
10. Sleep quantity T2	-.08	.07	-.17	.44**	-.27**	-.09	-.13	.09	-.28**	-								
11. Poor sleep quality T2	.27**	-.14	.44**	-.26*	.59**	.23*	.35**	-.27**	.56**	-.45**	-							
12. Daytime dysfunction T2	.53**	-.43**	.52**	-.25*	.31**	.54**	.66**	-.63**	.69**	-.21*	.37**	-						
13. Need frustration T3	.51**	-.33**	.26*	-.39**	.38**	.35**	.61**	-.45**	.44**	-.07	.30**	.35**	-					
14. Need satisfaction T3	-.33**	.43**	-.17	.19	-.26*	-.24*	-.39**	.47**	-.32**	.05	-.19	-.21	-.69**	-				
15. Stress T3	.35**	-.18	.46**	-.37**	.45**	.26*	.45**	-.27**	.52**	-.14	.35**	.29**	.57**	-.43**	-			
16. Sleep quantity T3	-.30**	.28*	-.14	.54**	-.30**	-.22	-.18	.17	-.12	.17	-.22	-.18	-.22*	.08	-.29**	-		
17. Poor sleep quality T3	.22*	-.11	.29**	-.38**	.48**	.19	.12	-.13	.24*	-.09	.47**	.13	.37**	-.35**	.49**	-.51**	-	
18. Daytime dysfunction T3	.16	-.25*	.06	-.19	.25*	.26*	.19	-.22*	.15	-.12	.19	.16	.54**	-.46**	.45**	-.27	.45**	-

Note. T1 = Wave 1; T2 = Wave 2; T3 = Wave 3.
* p<.05. ** p<.01.

Primary Analyses

Hypothesis 1: Examining Mean-Level Change. Univariate LCMs were estimated for all study variables. Table 2 provides an overview of the parameter estimates and fit indices for each model. On average, significant mean level change was found for all study variables from the pre- to exam period and from the exam to the post- exam period with one exception, namely sleep quantity for which no significant mean-level change was found from pre- to exam period. All negative outcomes (i.e., need frustration, stress, daytime dysfunction and poor sleep quality) displayed an inverted U-shaped pattern whereas all positive outcomes (i.e., need satisfaction & sleep quantity) displayed a U-shaped pattern. In other words, on average, as participants were exposed to an exam period, their experiences of need frustration, subjective stress, daytime dysfunction and poor sleep quality increased, while their experiences of need satisfaction decreased. Further, once the exam period was over, participants showed improvements in need experiences, stress and sleep outcomes (see Figure 1 for an illustration).

Hypothesis 2: Correlated Changes in Need Experiences, Stress and Sleep Outcomes. Due to the high correlation between changes in need satisfaction and changes in need frustration (i.e., Pre-exam to exam r =-.82, p < .001; Exam to Post-exam r = -.86, p <.001), we proceeded by analyzing the role of changes in need satisfaction and need frustration separately. There were four outcome variables (i.e., poor sleep quality, sleep quantity, daytime dysfunction, and stress), resulting in eight multivariate LCM's (i.e., 4 for need satisfaction & 4 for need frustration). Each model included both the level and change factors of one need-related variable (i.e., either need satisfaction or need frustration) and one outcome, allowing for the examination of correlations between the levels and the correlated change in need experiences and the four outcomes. All models fitted the data adequately with the average fit being RMSEA = .06, CFI = .96 and SRMR = .06 the poorest fit being RMSEA = .08, CFI = .93 & SRMR = .09. As shown in Table 3, the intercepts of need satisfaction and need frustration and the four outcomes were significantly interrelated in the expected direction. More importantly, as hypothesized, the changes were interrelated suggesting

Table 2

Parameter Estimates and Fit Indices of the Univariate Latent Change Models

	Parameter Estimates										
	Level		Change Pre-Exam to Exam Period			Change Exam to Post Exam Period			Fit Indices		
Variable	*M*	s^2	*M*	s^2	Range	*M*	s^2	Range	RMSEA	CFI	SRMR
Need satisfaction	3.43***	.22***	-.21***	.18***	-1.48 - .43	.59***	.19***	-.25 - 1.55	.04	.99	.08
Need frustration	2.36***	.39***	.18**	.27***	-1.02 - 1.15	-.65***	.28***	-1.9 - .31	.07	.99	.06
Stress	0.84***	.42***	.23***	.31***	-.74 - 1.27	-.66***	.38***	-2.44 - .13	.09	.98	.04
Daytime dysfunction	.01	.64**	.59***	-.79***	-.91 - 2.17	-.79***	1.01***	-3.35 - .65	.04	.99	.04
Sleep quantity	3.51***	.21***	-.09	.13	-.77 - .64	.16*	.36**	-1.25 - 1.19	.00	1	.12
Poor sleep quality	.00	.21***	.19***	.08**	-.17- .65	-.25***	.07**	-.84 - .05	.00	1	.03

Note. RMSEA = Root mean square error of approximation; CFI = Comparative fit index; SRMR = Standardized root mean square residual.
Indicators of poor sleep quality and daytime dysfunction use standardized scores.
*p<.05,**p <.01,***p < .001.

Figure 1. *Mean-level Changes in Stress across Time-points.*

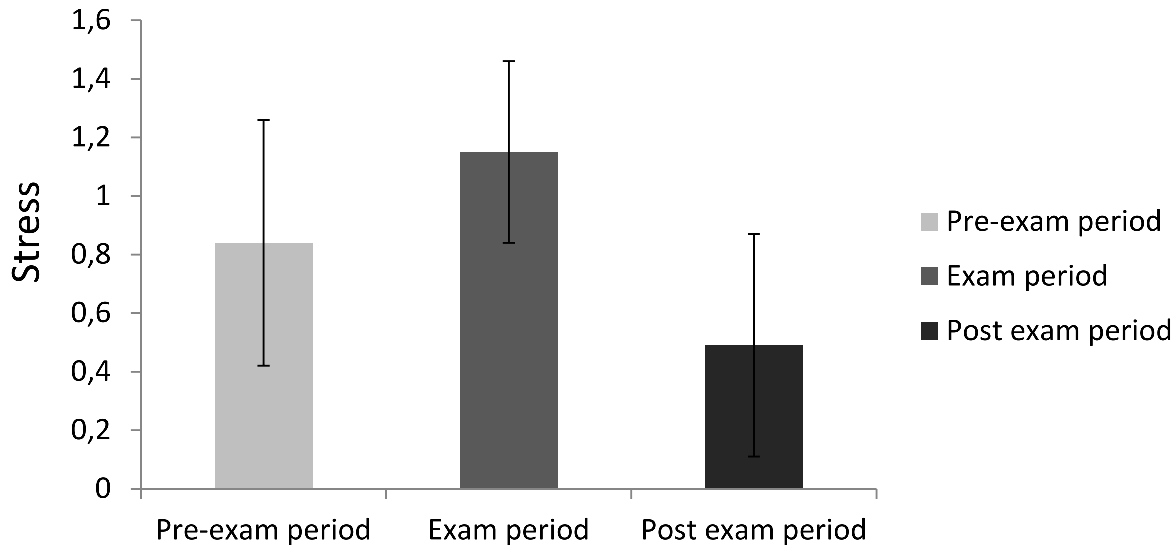


Table 3

Correlations between Level and Change Parameters from Multivariate Latent Change Models

	Need satisfaction			Need frustration		
	Level	Change12	Change23	Level	Change12	Change23
Poor sleep quality						
Level	**-.42*****	.01	-.04	**.49*****	-.04	.15
Change 12	.45***	**-.33***	-.08	-.30*	**.25***	-.03
Change 23	-.15	.27	**-.38***	-.09	-.14	**.39***
Sleep quantity						
Level	**.35****	-.11	-.14	**-.40***	.15	-.11
Change12	-.24	**.21**	.09	.27	**-.38***	.35
Change 23	.17	-.15	**-.08**	-.15	.23*	**-.11**
Daytime dysfunction						
Level	**-.75*****	.19	.31*	**.69*****	-.30*	-.12
Change12	.26*	**-.63*****	.29*	-.13	**.53*****	-.31**
Change23	.19	.27**	**-.58****	-.35**	-.09	**.66*****
Stress						
Level	**-.52*****	-.00	.23*	**.71*****	-.15	-.29**
Change12	.11	**-.42****	.08	-.23*	**.65*****	-.08
Change23	.17	.33*	**-.46*****	-.19*	-.33***	**.50*****

Note. Change 12 refers to changes from the pre exam to the exam period. Change23 refers to changes from the exam to the post exam period

p*<.05,*p* < .01, *p****<.001.

that the changes in need experiences and the outcomes occurred in tandem. For example, changes in both need frustration and poor sleep quality were positively related indicating that both variables increased in tandem from the pre- to the exam period and decreased in tandem from the exam to the post-exam period.

Hypothesis 3: Testing the Proposed Integrated Model. Latent variable scores of levels and changes calculated from the previous multivariate LCMs were used to examine whether the relationship between changes in need satisfaction and need frustration and changes in sleep and daytime dysfunction were accounted for by changes in stress. This set of analyses allowed us to examine whether, for example, an increase in need frustration from pre- to exam-period would relate to increases in poor sleep quality via increases in perceived stress. To test for the intervening role of stress, we estimated a model including direct effects from the need experiences (i.e., need satisfaction and need frustration) to the outcomes and indirect effects via stress. The final results of these models are shown in Figures 2a (i.e., sleep quality), 2b (i.e., sleep quantity) and 2c (i.e., daytime dysfunction). In each figure the coefficients above the line represent need satisfaction and the coefficients below the line represent need frustration. Further, the first coefficients reported represent changes from the pre- exam to the exam period and the second coefficients represent changes from the exam to the post exam period.

Given that these models were saturated, therefore resulting in a perfectly fitting model, our primary interest was in the direct and indirect associations between the study variables. With respect to poor sleep quality (i.e., Figure 2a), the association with changes in need experiences was fully accounted for by changes in stress in all cases except one. That is, the association with changes in need satisfaction from the exam to the post exam period was only partially accounted for by changes in stress. To illustrate, the increase in need frustration from the pre- to the exam period co-varied with an increase in poor sleep quality which could be explained by the increase in experienced stress during this transition (as reflected in the first coefficients below the line, that is., .70 and .68). With regard to changes in daytime dysfunction, the associations with changes in need

Figure 2a. *Changes in Psychological Need Experiences Predicting Changes in Poor Sleep Quality via Changes in Stress.*

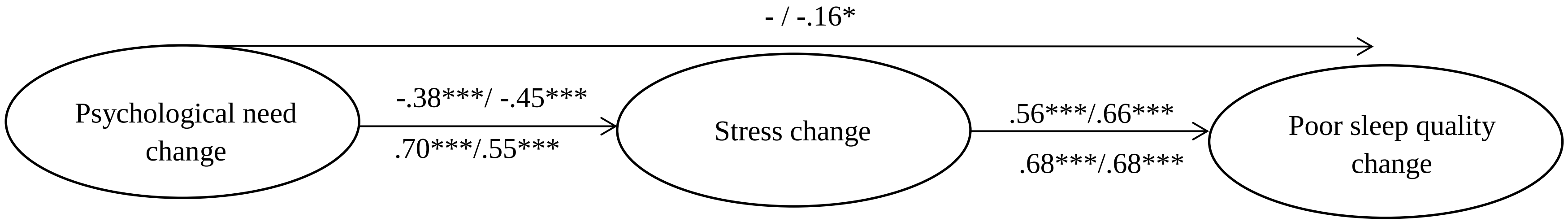


Figure 2b. *Changes in Psychological Need Experiences Predicting Changes in Sleep Quantity via Changes in Stress.*

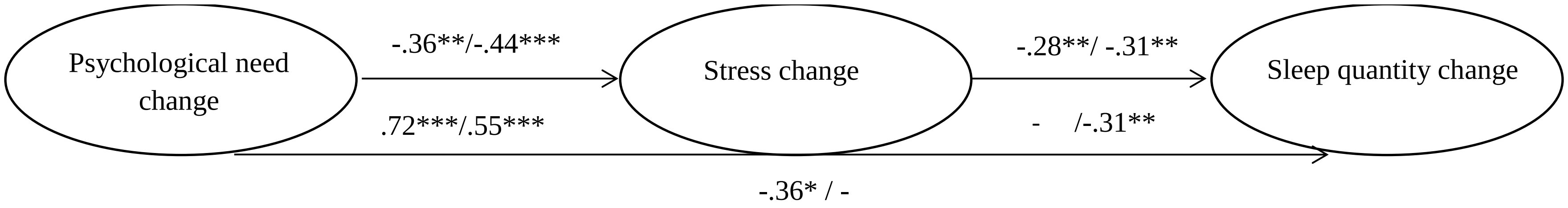
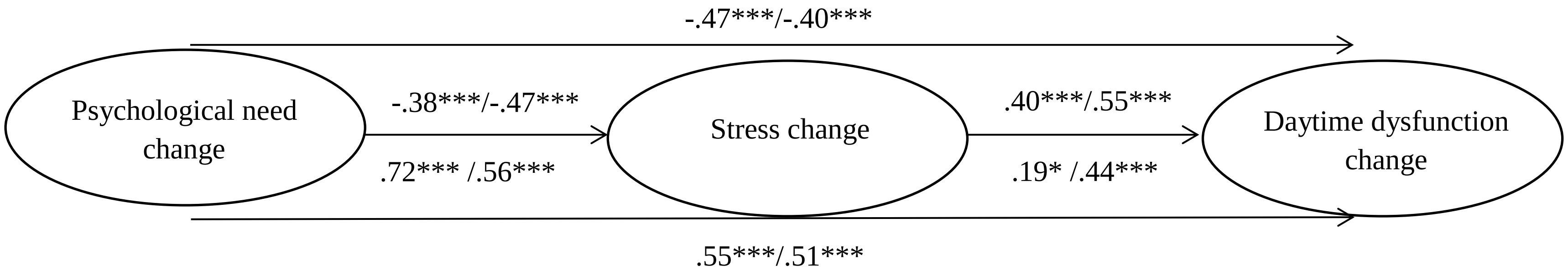


Figure 2c. *Changes in Psychological Need Experiences Predicting Changes in Daytime Dysfunction via Changes in Stress.*



Note. *p<.05,**p < .01, p***<.001.
Coefficients above the line represent need satisfaction and coefficients below the line represent need frustration.
The first coefficients reported represent changes from the pre- to the exam period and the second coefficients represent changes from the exam to the post exam period.

experiences were partially accounted for by changes in stress across all changes. In other words, the increase in stress from the pre- to the exam period and the subsequent decrease from the exam to the post-exam period partially explained why changes in need satisfaction and changes in need frustration related to changes in daytime dysfunction during these transitions. Finally, with regard to changes in sleep quantity, the only significant direct association was with changes in need frustration from pre- to the exam period, which was not accounted for by changes in stress. Across all other changes the association with changes in need experiences was indirect via changes in stress. All indirect effects were significant across all changes (range CI 95% [-.42; .50]) with one exception, namely the indirect effect of changes in need frustration on changes in sleep quantity via changes in stress from the pre- to the exam period.

Discussion

Consistent with previous research (e.g., Galambos et al., 2009; Galambos et al., 2010; Galambos et al., 2013), the present study found sleep in emerging adulthood and, more specifically in a sample of university students, to vary considerably within individuals. As pointed out by Galambos and Dalton (2009) such within-person fluctuations beg for explanation. That is, there is a need to identify predictors with equal variability that evolve in tandem with emerging adults' quality and quantity of sleep. In the present study we aimed to extend previous findings by considering psychological predictors of university students' sleep from an established psychological framework during a particularly relevant and potentially stressful period. Specifically, we investigated (a) the covariation between changes in the satisfaction and frustration of one's basic psychological needs, as conceived within SDT (Deci & Ryan, 2000), and changes in emerging adults' day and sleep-related functioning and (b) the intervening role of changes in stress in these associations. The results revealed several important findings.

First, meaningful mean-level changes were observed as university students prepared for, were exposed to and emerged from an exam period. During the exam period participants reported increases in negative outcomes (i.e., need frustration, poor sleep quality and daytime dysfunction) and decreases in positive outcomes (i.e., need satisfaction). As participants emerged from the exam period the reverse pattern of findings was observed (i.e., decreases in negative outcomes and increases in positive outcomes). In other words, both need-based and sleep-related functioning deteriorated as participants moved from the pre- to the exam period, and returned to and even went beyond the initial levels once the exam period was over. One explanation for the finding that need-based and sleep functioning was most favorable during the post-exam assessment is perhaps because the post-exam assessment took place during a holiday period, whereas the pre-exam assessment took place during the academic semester when academic demands were likely increasing. Overall, these mean-level changes in the outcomes were in line with our expectations and are indicative of the dynamic nature of the variables under investigation.

Second, we then examined whether these within-person changes in psychological need experiences were associated with within-person changes in the day and sleep outcomes across time. This appeared to be the case. On average, as university students went through an exam period, their sleep and daytime functioning fluctuated in parallel with their need experiences such that increases in need frustrating experiences and decreases in need satisfying experiences went hand in hand with worse sleep and daytime functioning. Moreover, as university students emerged from the exam period, an improvement in their need experiences was accompanied by a rise in their quality and quantity of sleep as well as more adaptive daytime functioning. Presumably, during the day the exposure to need-thwarting experiences erodes energy levels and elicits more cognitive and somatic arousal, which in turn likely requires more emotional processing which then interferes with quality and quantity of sleep at night. It should be noted that only changes in need frustration, and not need satisfaction, were associated with changes in sleep quantity. One possible explanation for the lack of an association between need satisfaction and sleep quantity may perhaps be that the vitalizing effect of psychological need satisfaction (e.g., Reis, Sheldon, Gable, Roscoe, & Ryan 2000) may lead university students to be satisfied with the quality of their sleep even when not sleeping the required amount. An alternative explanation is that sleep is a behavior for which there is a limit. Hence, perhaps once individuals have slept the required number of hours, need satisfaction may not co-vary with higher quantity of sleep.

Finally, the assessment of stress allowed us to formally examine whether changes in stress would account for the relation between changes in need experiences and changes in the outcomes. In general, the rise and fall in stress as university students moved in and out of the exam period was able to explain why shifts in need experiences related to shifts in both day and sleep-related outcomes. While the association between stress and poor sleep has already been demonstrated in various previous studies (e.g., Galambos et al., 2010; Galambos et al., 2013; Zunhammer et al., 2014), the present results build on previous findings by demonstrating that changes in psychological need experiences contributed to changes in stress when exposed to a potentially stressful event. Hence, the present findings identify specific experiences which may lead to an event, such as an exam period, to be appraised by students as threatening thereby engendering symptoms of stress and subsequent sleep disturbances. Moreover, the identification of need experiences as potential sources of stress may inform interventions which seek to help university students to reduce stress by providing specific experiences which can be targeted through intervention (e.g., Weinstein, Khabbaz, & Legate, 2016).

Although satisfactory evidence was provided for the intervening role of stress, two findings should be highlighted. First, in the integrated models, need experiences continued to yield a direct association with daytime dysfunction, suggesting that other explanatory variables, apart from stress, should be considered. One primary candidate is mindfulness (Brown & Ryan, 2003). Need frustrating experiences likely erode available energy resulting in a more inward looking attitude and a decreased awareness of what is occurring in the present moment. This decreased awareness, or lack of a mindful approach, may in turn partly explain why need frustrating experiences may translate into poorer daytime functioning or even poorer quality sleep at night (see Campbell et al., 2015; Hulsheger et al., 2014). Second, changes in need frustration from the pre- to the exam period also continued to yield a direct association with changes in sleep quantity, which was not accounted for by changes in stress. Perhaps university students respond to need frustration during exam periods by engaging in compensatory behaviors that they hope will provide some need fulfillment like for example, spending excessive time on social media, which in turn may lead to shorter sleep duration. Future studies could assess other self-regulatory behaviors, such as sleep hygiene, in order to obtain a better understanding of how need frustration obstructs sleep duration.

Practical Implications

The present findings indicate that during exam periods students are likely to experience increased frustration of their basic psychological needs, which in turn is likely to be accompanied by increases in stress and sleep disturbances. These findings emphasize the dynamic and changeable nature of need-based experiences and suggest that psychological needs may be especially susceptible to intervention. In line with this, a recent 1 week intervention study which sought to help individuals highly vulnerable to distress (i.e., Syrian refugees) identify and participate in daily need-satisfying activities demonstrated that participants reported significant decreases in stress post-intervention (Weinstein, Khabbaz, & Legate, 2016). Hence, short-term interventions which encourage students to engage in small, manageable daily activities which satisfy basic psychological needs may help to reduce stress and sleep difficulties during exam periods. In addition to encouraging engagement in need satisfying activities, students could also be helped to become more aware of and less reactive to experiences of need frustration. This could be achieved for example, by encouraging students to adopt techniques which facilitate accepting, non-judgmental present moment awareness (i.e, mindfulness), such as meditation practice.

Limitations and Suggestions for Future Research

This study had several limitations that can be overcome in future research. First, all measures were self-reported which can inflate observed associations due to shared method variance. Moreover, reliance on self-reports may have undermined validity for certain measures such as sleep duration. These limitations could be overcome by using objective measures such as actigraph watches to assess sleep in future studies. Second, the analyses performed do not allow for conclusions about the direction of effects. For example, poor sleep during exam periods may not only result from, but may also contribute to stress, which in turn may elicit need frustration. Experimental work, involving either sleep deprivation (e.g., Cote et al., 2009) or random exposure to a need satisfying or need frustrating event may allow one to draw causal conclusions. Third, as our sample was fairly homogenous, future studies should examine whether these findings generalize to emerging adults from more diverse socio-economic and cultural backgrounds. Further, there was substantial variation in the rate of change in the study variables between individuals. Future studies could examine predictors of these different rates of change between individuals and also potential moderators of the relation between psychological needs and sleep outcomes. For example, future studies could explore the moderating role of individuals' dispositional mindfulness (Brown & Ryan, 2003) or self-critical perfectionism (Blatt, 2004) as both are likely to influence reactivity to need experiences. Finally, given our findings future research could also examine whether a short-term intervention which aims to foster need satisfaction, would help students to be more resilient to stress and sleep disturbances during exam periods.

Conclusion

In sum, the present study underscores the dynamic interplay between university students' need experiences, daytime functioning and quality and quantity of sleep during an exam period. The findings indicate that during weeks in which university students feel pressured and ineffective in their activities and disconnected from close others, their daytime functioning and sleep is likely to be impaired. Further, subjective stress was found to partially account for the relation between need experiences and the day and sleep outcomes, indicating that stress plays a critical explanatory role. These findings imply that university students should be helped to recognize need frustrating experiences and taught skills to minimize their impact by for example adopting a more mindful approach. Moreover, it seems particularly important that university students are provided with support in adopting such coping skills during times when experiences of need frustration and stress may be almost unavoidable (e.g., exam periods).

References

Ahrberg K, Dresler M, Niedermaier S, Steiger A, Genzel L (2012) The interaction between sleep quality and academic performance. *Journal of Psychiatric Research, 46*, 1618–1622. doi: 10.1016/j.jpsychires.2012.09.008

Arnett, J. J. (2000). Emerging Adultho:od: A theory of development from the late teens through the twenties. *American Psychologist*, *55*, 469-480. doi: 10.1037//0003-066X.55.5.469

Bartholomew, K. J., Ntoumanis, N., Ryan, R. M., & Thøgersen-Ntoumani, C. (2011). Psychological need thwarting in the sport context: Assessing the darker side of athletic experience. *Journal of Sport & Exercise Psychology, 33*, 75-102.

Beyers, W., & Goossens, L. (2008). Dynamics of perceived parenting and identity formation in late adolescence. *Journal of Adolescence, 31*, 165-184. doi: 10.1016/j.adolescence.2007.04.003

Blatt, S. J. (2004). *Experiences of Depression: Theoretical, Clinical and Research Perspectives*. Washinton, DC: American Psychological Association.

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology*, *84*, 822–848. doi: 10.1037/0022-3514.84.4.822

Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index – a new instrument for psychiatric practice and research. *Psychiatry Research*, *28*, 193–213. doi: 10.1016/0165-1781(89)90047-4

Campbell, R., Vansteenkiste, M., Delesie, L.M., Mariman, A. N., Soenens, B., Tobback, E., Van der Kaap-Deeder, J., & Vogelaers, D. P. (2015). Examining the role of psychological need satisfaction in sleep: A Self-Determination Theory perspective. *Personality and Individual Differences*, *77*, 199-204. doi: 10.1016/j.paid.2015.01.003

Chen, B., Vansteenkiste, M., Beyers, W., Boone, L., Deci, E. L., Duriez, B. Lens, W., Matos, L., Mouratidis, A., Ryan, R. M., Sheldon, K. M., Soenens, B., Van Petegem, S., & Van der Kaap-

Deeder, J., Verstuyf, J (2015). Basic psychological need satisfaction, need frustration, and need strength across four cultures. *Motivation and Emotion*, *39,* 216-236. doi: 10.1007/s11031-014-9450-1

Cote, K. A., Milner, C. E., Smith, B. A., Aubin, A. J., Greason, T. A., Cuthbert, B. P., Wiebe, S., & Duffus, S. E. G. (2009). CNS arousal and neurobehavioral performance in a short-term sleep restriction paradigm. *Journal of Sleep Research*, *18*, 3, 291 – 303. doi: 10.1111/j.1365-2869.2008.00733.x

Dahl, R. E., & Lewin, D. S. (2002). Pathways to adolescent health sleep regulation and behavior. *Journal of Adolescent Health, 31*, 175–184. doi: 10.1016/S1054-139X(02)00506-2

Deci, E. L. & Ryan, R. M. (2000). The ‘what’ and ‘why’ of goal pursuits: Human needs and the self determination of behavior. *Psychological Inquiry*, *11*, 227-268. doi: 10.1207/S15327965PLI1104_01

Doane, L.D., Gress-Smith, J.L., & Breitenstein, R. S. (2015). Multi-method assessments of sleep over the transition to college and the associations with depression and anxiety symptoms. *Journal of Youth and Adolescence,44,* 389-404. doi: 10.1007/s10964-014-0150-7

Galambos, N. L., Dalton, A. L., & Maggs, J. L. (2009). Losing sleep over it: Daily variation in sleep quantity and quality in Canadian students’ first semester of university. *Journal of Research on Adolescence, 19,* 741-761.

Galambos, N.L., Howard, A.L., & Maggs, J.L. (2010). Rise and fall of sleep quantity and quality with student experiences across the first year of university. *Journal of Research on Adolescence, 21*, 342-349. doi: 10.1111/j.1532-7795.2010.00679.x

Galambos, N.L., Vargas Lascano, D.I., Howard, A.L., Maggs, J.L. (2013). Who sleeps best? Longitudinal patterns and covariates of change in sleep quantity, quality, and timing across four university years. *Behavioral Sleep Medicine, 11,* 8-22. doi: 10.1080/15402002.2011.596234

Guastella, A.J., and Moulds, M. L. (2007). The impact of rumination on sleep quality following a stressful life event. *Personality and Individual Differences*, *42,* 1151-1162. doi: 10.1016/j.paid.2006.04.028

Harvey, A. G. (2008). Insomnia, psychiatric disorders, and the transdiagnostic perspective. *Journal of American College Health*, *17*, 299-303. doi: 10.1111/j.1467-8721.2008.00594.x

Hertzog, C., Dixon, R. A., Hultsch, D. F., & MacDonald, S. W. S. (2003). Latent change models of adult cognition: Are changes in processing speed and working memory associated with changes in episodic memory? *Psychology and Aging, 18,* 755-769. doi: 10.1037/0882-7974.18.4.755

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6,* 1-55. doi: 10.1080/10705519909540118

Hulsheger, U. R., Lang, J.W.B., Depenbrock, F., Fehrmann, C., Zijlstra, F.R.H., & Alberts, H.J.E.M. (2014). The power of presence: The role mindfulness at work for daily levels and change trajectories of psychological detachment and sleep quality. *Journal of Applied Psychology, 99,* 1113-1128. doi: 10.1037/a0037702

Kline, R. B. (2005). Principles and practice of structural equation modeling. New York: Guilford Press.

Little, R. J. A., & Rubin, D. B. (1987). *Statistical analysis with missing data*. New York: Wiley.

Little, T. D., Cunningham, W. A., Shahar, G., & Widaman, K. F. (2002). To parcel or not to parcel: Exploring the question, weighing the merits. Structural Equation Modeling, 9, 151–173.

Lovibond, S. H., & Lovibond, P. F. (2004). Manual for the Depression Anxiety Stress Scales, second edition, Psychology Foundation, Sydney.

Lund H. G., Reider, B. D., Whiting, A. B., & Prichard, J. R. (2010). Sleep patterns and predictors of disturbed sleep in a large population of college students. *Journal of Adolescent Health, 46,* 124-132. doi: 10.1016/j.jadohealth.2009.06.016

Quested, E., Bosch, J., Burns, V.E., Cummings, J., Ntoumanis, N., & Duda, J.L. (2011). Basic psychological need satisfaction, cognitive appraisals, and dancers' hormonal and emotional responses. *Journal of Sport & Exercise Psychology, 33,* 828-46.

Reeve, J., & Tseng, C.-M. (2011). Cortisol reactivity to a teacher's motivating style: the biology of being controlled versus supporting autonomy. *Motivation and Emotion, 35,* 63-74. doi: 10.1007/s11031-011-9204-2

Reis, H. T, Sheldon, K. M., Gable, S. L., Roscoe, J., & Ryan, R. M. (2000). Daily well-being: The role of autonomy, competence, and relatedness. *Personality and Social Psychology Bulletin*, *26*, 419-435. doi: 10.1177/0146167200266002

Ryan, R. M., & Frederick, C. M. (1997). On energy, personality, and health: Subjective vitality as a dynamic reflection of well-being. *Journal of Personality*, *65*, 529–565. doi: 10.1111/j.1467-6494.1997.tb00326.x

Ryan, R.M., Bernstein, J.H., & Brown, K.W. (2010). Weekends, work, and well-being: psychological need satisfactions and day of the week effects on mood, vitality, and physical symptoms. *Journal of Social and Clinical Psychology*, *29,* 95-122.

Sladek, M.R., & Doane, L.D. (2015). Daily diary reports of social connection, objective sleep, and the cortisol awakening response during adolescents' first year of college. *Journal of youth and adolescence, 44*, 298-316. doi: 10.1007/s10964-014-0244-2

Sörbom, D. (1975). Detection of correlated errors in longitudinal data. *British Journal of Mathematical and Statistical Psychology, 28,* 138-151.

Taylor, D.J., Vatthauer, K.E., Bramoweth, A.d., & Ruggero, C. (2013). The role of sleep in predicting college academic performance: Is it a unique predictor? *Behavioral Sleep Medicine, 11*, 159-172. doi: 10.1080/15402002.2011.602776

Urner, M., Tornic, J., & Bloch, K.E. (2009). Sleep patterns in high school and university students: A longitudinal study. *Chronobiology International*, *26*(6), 1222-1234. doi: 10.1080/07420520903244600

Van der Kaap-Deeder, J., Vansteenkiste, M., Van Petegem, S., Raes, F., & Soenens, S. (2016). On the integration of need-related autobiographical memories among late adolescents and late adults: The role of depressive symptoms and self-congruence. *European Journal of Personality*.

Vansteenkiste, M., & Ryan, R. M. (2013). On psychological growth and vulnerability: Basic psychological need satisfaction and need frustration as a unifying principle. *Journal of Psychotherapy Integration, 23,* 263-280. doi: 10.1037/a0032359

Verstuyf, J., Vansteenkiste, M., Soenens, B., Boone, L., & Mouratidis, A. (2013). Daily ups and downs in women's binge eating symptoms: The role of basic psychological needs, general self-control, and emotional eating. *Journal of Social and Clinical Psychology*, *32,* 335-361.

Watson, D., O’Hara, M. W., Simms, L. J., Kotov, R., & Chmielewski, M. (2007). Development and validation of the Inventory of Depression and Anxiety Symptoms (IDAS). *Psychological Assessment*, *19*, 253–268. doi: 10.1637/1040-3590.19.3.253

Weinstein, N., & Ryan, R. M. (2011). A self-determination theory approach to understanding stress incursion and responses. *Stress and Health*, *27,* 4-17. doi: 10.1002/smi.1368

Weinstein, N., Khabbaz, F., & Legate, N. (2016). Enhancing need satisfaction to reduce psychological distress in Syrian refugees. *Journal of Consulting and Clinical Psychology* PMID 27018533. doi: 10.1037/ccp0000095

Zimmerman, L.K. (2011). Chronotype and the transition to college life. *Chronobiology International*, *28*(10). 904-910. doi: 10.3109/07420528.2011.618959

Zunhammer, M., Eichhammer P., & Busch, V. (2014). Sleep quality during exam stress: The role of alcohol, caffeine and nicotine. *PloS One, 9*(10), e109490. doi: 10.1371/journal.pone.0109490

CHAPTER 4

The Role of Basic Psychological Need Satisfaction, Sleep and Mindfulness in the Health Related Quality of Life of People Living with HIV.[1]

Research has not yet examined the relationship between psychological need satisfaction, sleep, mindfulness and health-related quality of life (HRQOL) in people living with HIV (PLHIV). This cross-sectional study (*N* = 101; 84% male; Mean age = 45.48, SD = 12.75) found need satisfaction to relate positively to physical and mental health. Sleep quality fully mediated the association with physical health and partially mediated the association with mental health. Further, mindfulness related to higher sleep quality through higher need satisfaction. Findings underscore the role of need satisfaction in determining HRQOL and sleep quality in PLHIV and suggest that mindfulness may facilitate need satisfaction.

[1] Campbell, R., Vansteenkiste, M., Delesie, L., Soenens, B., Tobback, E., Vogelaers, D., & Mariman, A. (2016). The role of basic psychological need satisfaction, sleep, and mindfulness in the health related quality of life of people living with HIV. *Journal of Health Psychology*.

Introduction

The advent of continuous antiretroviral therapy (cART) greatly transformed the outlook for people living with HIV (PLHIV). While once considered a death sentence, HIV is now a chronic yet manageable disease (Oberjé, Dima, Van Hulzen, Prins, 2015). However, despite these advances living with HIV still presents many challenges including life-long adherence to medication, adverse treatment side effects, and psychosocial difficulties often resulting from stigma and discrimination (Gakhar, Kamali & Holodniy, 2013; Bravo, Edwards, Rollnick, & Elwyn, 2010). Because living longer does not necessarily equate to “living well” health-related quality of life (HRQOL), defined as perceived physical and mental health over time (CDC, 2016), has become an important outcome in HIV research (Lin, Wu & Revicki, 2002; Degroote, Vogelaers, Vermeir, et al., 2013). Moreover, an increasing number of studies have begun to examine the role of psychosocial factors, such as social support (Uphold, Holmes, Reid, et al., 2007) and stigma (Peltzer, 2012) in predicting HRQOL.

In the present study we draw upon Self-Determination Theory (SDT; Deci & Ryan, 2000; Vansteenkiste & Ryan, 2013), a broad theory of human motivation and the factors that promote versus impede human flourishing. SDT provides a useful framework for examining predictors of HRQOL as it specifies the universal and inherent psychological needs for autonomy, competence, and relatedness as essential for optimal functioning. Autonomy involves experiencing a sense of volition and self-endorsement in one’s behavior, competence involves feeling capable and effective in achieving desired outcomes and relatedness involves experiencing reciprocal care and closeness with others. The relation between these psychological needs and wellness is well-documented with various studies showing need satisfaction to be positively related to well-being (e.g., life satisfaction) and negatively related to ill-being (e.g., depression, anxiety) (Deci & Ryan, 2000). Similar findings have emerged across diverse domains and cultures and at both the inter- and intra-personal level (Vansteenkiste & Ryan, 2013).

There is some evidence that these fundamental psychological needs play a role in determining the HRQOL of PLHIV. For instance, social support, which is likely conducive to the need for relatedness, relates positively to HRQOL (Uphold et al., 2007), whereas stigma, which likely thwarts all three needs, is negatively associated with HRQOL (Peltzer, 2012). Further, a qualitative study of HIV-positive women indicated that feeling competent in managing one's condition and experiencing warmth with one's care-giver were important determinants of the decision to enter into care, whereas re-establishing autonomy emerged as a key element for long-term engagement in treatment (Quinlivian, Messer, Adimora, et al., 2013). Moreover, care-giver support for HIV-positive patients' need for autonomy has been shown to predict treatment adherence (Kennedy, Goggin, & Nollen, 2004). Finally, in a qualitative study of HIV-positive youth, decisions to disclose HIV status were dependent on whether the youth perceived the context of the disclosure as being supportive of their psychological needs (Gillard & Roark, 2013). This is an important finding given that status disclosure yields several benefits including increased social support (Wong, Van Rooyen, Modiba, Richter, et al., 2009) and the development of more adaptive coping strategies (Medley, Kennedy, Lunyolo, & Sweat, 2009).

Although psychological need satisfaction is robustly related to well-being (Deci & Ryan, 2000; Vansteenkiste & Ryan, 2013) mechanisms accounting for this association are yet to be examined. One possible pathway may be through quality and quantity of sleep. Approximately 58% of PLHIV are estimated to suffer from sleep disturbances (Wu, Wu, Lu, et al., 2015) a problem which has been linked to a number of adverse outcomes including fatigue, depression, and reduced quality of life in HIV-positive individuals (Phillips, Mock, & Bopp, 2006; Phillips, Sowell, Boyd, et al., 2005; Phillips, Sowell, Rojas, et al., 2004). These sleep disturbances reported by PLHIV may be at least in part due to their confrontation with need frustrating experiences (e.g., stigmatic or hostile reactions). For example, psychological need frustration resulting from unjust treatment or discrimination after HIV status disclosure likely leads to stress which may negatively impact on quality and quantity of sleep.

In line with this, previous research in a non-clinical heterogeneous sample indicated that individuals with low psychological need satisfaction reported poorer sleep quality and somewhat shorter sleep duration (Campbell, Vansteenkiste, Delesie, et al., 2015). Further, a longitudinal study among university students indicated that increases in psychological need frustration were associated with increases in poor sleep quality and a reduction in sleep quantity through increases in perceived stress (Campbell, Vansteenkiste, Beyers, et al., 2016). However, despite the relevance of basic psychological needs to sleep, these associations have not been examined in PLHIV.

Given the preliminary evidence suggesting that psychological need satisfaction may play a salutary role in the sleep and HRQOL of PLHIV, the question can be raised as to which factors relate to enhanced psychological need satisfaction. One likely predictor of need satisfaction, which has received growing attention within the health psychology literature, is mindfulness. One reason for this rising interest in mindfulness, which is conceptualized as an open and receptive awareness of present moment experiences (Brown & Ryan, 2003), is that it has consistently been shown to display salutary relations with indicators of both physical and mental health within a variety of clinical (e.g., Costa, Pinto-Gouveia & Marôco, 2016) and non-clinical populations (e.g., Brown & Ryan, 2003; Xu, Oei, Liu, Wang & Ding, 2014). Moreover, although the evidence is still somewhat inconsistent, recent findings suggest that mindfulness may also be linked to bio-markers of well-being, including cortisol levels (e.g., O' Leary, O'Neill, & Dockray, 2015).

With regard to psychological need satisfaction, the increased awareness typical of mindful individuals likely allows for the selection of more need-satisfying activities, for better attunement to activities such that greater need satisfaction is derived and also for less emotional reactivity to need frustrating experiences. Accordingly, a few previous studies found mindfulness to be positively associated with need satisfaction (Brown & Ryan, 2003; Campbell et al., 2015). Further, need satisfaction was found to account for the relation between mindfulness and poor sleep quality (Campbell et al., 2015). Although mindfulness has been shown to be negatively related to ill-being (e.g., depression) in PLHIV (Moskowitz, Duncan, Moran, et al., 2015) the relation with need satisfaction and sleep-related functioning has not yet been examined.

In sum, although previous research examining sleep and HIV-related outcomes within the SDT literature is rather limited, there is some evidence to suggest that mindfulness and psychological need satisfaction may be implicated in the sleep and health related quality of life of

PLHIV. Thus, in the present cross-sectional study we aimed to shed further light on these issues by examining two aims in a sample of PLHIV. In line with Kline’s (2005) recommendations, due to our limited sample size we examined our aims in two parts to reduce the number of parameters in our models and limit model complexity. The first aim was to examine the outcomes associated with need satisfaction in PLHIV. Specifically, first we examined whether psychological need satisfaction related to indicators of HRQOL and, second, whether quality and quantity of sleep would account for (i.e., mediate) the relation between need satisfaction and the indicators of HRQOL. We expected need satisfaction to relate to higher physical and mental health (Hypothesis 1). Further, we expected need satisfaction to relate to the two indicators of HRQOL through higher quality and quantity of sleep, although in line with Campbell et al. (2015), we expected the relation with sleep quantity to be less pronounced (Hypothesis 2). The second aim was to examine the role of mindfulness in predicting need satisfaction and quality and quantity of sleep. Consistent with Campbell et al. (2015), we expected mindfulness to be uniquely related to higher sleep quality (Hypothesis 3) through higher psychological need satisfaction (Hypothesis 4).

Method

Participants and procedure

All participants were recruited during a routine check-up by their physician at the AIDS Reference Centre within the Department of General Internal Medicine of Ghent University Hospital. After registering interest in the study, all participants were referred to a research assistant who explained the purpose and requirements of the study in greater detail. Participants were eligible for inclusion if they were HIV+, older than 18 years of age, Dutch-speaking and had a CD4 T-lymphocyte count > 250 cells/µl. Individuals were excluded if they had children under the age of 3 or were employed in shift work, given their likely detrimental impact on sleep. Signed informed consent was provided by all participants and the study was approved by Ghent University Hospital’s Ethical Review Board

Measures

Demographic and clinical variables. Age, gender, level of education, nationality, marital status and employment status were reported by all participants. Clinical data (i.e., CD4+ cell count) was assessed as part of routine clinical care.

Basic Psychological Need Satisfaction and Need Frustration Scale (BPNSNFS). *S*atisfaction of the basic psychological needs for autonomy, competence and relatedness was assessed using the BPNSNFS (Chen et al., 2015). All participants rated whether they felt their needs for autonomy, competence, and relatedness were satisfied or frustrated over the past month on a scale of 1 to 5. The scale consists of 24 items, 8 items per need, 4 of which assess need satisfaction and 4 need frustration. Because mean scores of the 12 items assessing need satisfaction and the 12 items assessing need frustration showed similar relations with all study variables, yet in the opposite direction, we proceeded by using a composite score of need satisfaction in all subsequent analyses. This was done by reverse scoring the 12 items assessing need frustration and then creating three separate need scores by averaging the 8 items assessing autonomy (α = .87), competence (α = .84), and relatedness (α = .84). Next, consistent with previous research a composite score of need satisfaction (α = .93) was created by averaging the sum of the three need variables (Campbell et al., 2015; Deci, Ryan & Gagné, 2001).

Medical Outcomes Study 36-Item Short Form Health Survey (MOS SF-36). Physical and mental health was assessed using the MOS SF-36 (Ware & Sherbourne, 1992), which taps into 8 different health domains. A global score for physical health was created by averaging the scores on physical functioning, role limitations due to physical health, bodily pain and general health, whereas a global score for mental health by averaging the scores on the domains role limitations due to emotional problems, emotional well-being, social functioning and energy/fatigue. Higher global scores represent better physical/mental health status.

Pittsburgh Sleep Quality Index (PSQI). The PSQI (Buysse, Reynolds, Monk et al., 1989) was used to assess quality and quantity of sleep over the past month. The PSQI consists of 19 items which generate 7 component scores: poor subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of hypnotics, and daytime dysfunction. However, because our primary interest was in qualitative and quantitative indicators of sleep, the daytime dysfunction component was omitted from subsequent analyses. Because higher scores on the PSQI components are indicative of poorer sleep, the sleep duration and habitual sleep efficiency were reverse coded such that higher scores represented a higher amount of the labeled construct.

Mindfulness Attention Awareness Scale (MAAS). Dispositional mindfulness was assessed using the MAAS (Brown & Ryan, 2003). The scale consists of 15 items which were rated on a scale of 1 to 6 (*almost never*). The MAAS had good reliability (α = .93).

Statistical Analyses

The two research aims were examined by testing path models (with manifest variables) using Mplus7 with maximum-likelihood as estimator. Model fit was assessed using the χ^2 test, the comparative fit index (CFI), the standardized root mean square residual (SRMR), and the root mean square error of approximation (RMSEA). An acceptable fit was indicated by χ^2/df ratio of 2 or below, CFI values of .90 or above, and SRMR and RMSEA values of around .08 or below (Hu & Bentler, 1999; Kline, 2005). Patient characteristics (i.e., age, gender, CD4 count & employment status) were controlled for in all models.

We began by testing hypotheses 1 and 2 thereby examining the outcomes associated with need satisfaction. In a first model we examined the relation between need satisfaction and physical/mental health (Hypothesis 1) and in a second model we investigated the intervening role of quality and quantity of sleep in these associations (Hypothesis 2). Next, we proceeded to test hypotheses 3 and 4 thereby examining the role of mindfulness in predicting need satisfaction and the sleep outcomes. Specifically, we tested a third model in which we examined the relation between mindfulness and quality and quantity of sleep (hypothesis 3), and a fourth model in which we examined the intervening role of need satisfaction in these relations (Hypothesis 4). To test for mediation (i.e., Hypotheses 2 & 4) we followed Holmbeck's recommendations (1997) by testing (a) a direct effect model by adding paths between the independent variable and the dependent variable (i.e., Hypotheses 1 & 3), (b) a full mediation model by only including indirect paths via the mediator and, (c) a partial mediation model by adding the direct paths between the independent variable and the dependent variable back in. Full mediation is demonstrated when the addition of a direct paths in model three does not lead to an improved fit compared to the second model.

In line with previous research (Campbell et al., 2015; Deci et al., 2001) when testing the role of need satisfaction we used a composite score of need satisfaction by averaging the mean score of the three needs. Further, also consistent with Campbell et al. (2015) a composite score was created for poor sleep quality, by computing the mean of the sleep quality, sleep disturbances, sleep latency and use of sleep medication component scores from the PSQI, and for sleep quantity by computing the mean of the sleep duration and habitual sleep efficiency components from the PSQI.

Results

Preliminary analyses

Participants. A total of 144 patients met the inclusion criteria and agreed to participate. One hundred and one participants completed the questionnaire, resulting in a response rate of 70.14%. All participants were of Belgian nationality, 84% were male and 67.4% were homosexual. The average age of the sample was 45.48 (ranging from 21 to 75; SD = 12.75). Seventy percent were employed and 46% had completed a form of higher level education. Forty percent were single, 31% married, 2% widowed and 4% divorced. Mean time since HIV diagnosis was 10.94 years, ranging from 2 to 33 years. The mean CD4 count of the sample was 640.25 (ranging from 271 to 1830; SD = 262.75).

Correlations. The means, standard deviations and correlations between all the study variables are displayed in Table 1. The subscales for autonomy, competence and relatedness were highly correlated and showed similar relations with mindfulness and the sleep and HRQOL outcomes.

Patient characteristics. The relation between the participants' background characteristics and the outcomes was examined using a MANCOVA with employment status and gender as fixed factors, age and CD4 T-lymphocyte count as co-variates and the sleep and HRQOL outcomes as dependent variables. Neither gender, $F(8,38) = .65$, *ns,* employment status, $F(8,38) = .44$, *ns,* age,

$F(8,38) = 1.45$, *ns,* or CD4 T-lymphocyte count[2], $F(8,38) = .42$, *ns,* yielded a significant multivariate effect.

Primary analyses

Hypothesis 1: Examining the need satisfaction – HRQOL relation. First a direct effect model was tested by allowing paths from the need satisfaction composite to global physical and mental health. The two HRQOL indicators were allowed to correlate. Need satisfaction related positively to both global physical ($\beta = .27$, $p < .01$) and mental health ($\beta = .54$, $p < .001$). Given that this model was fully saturated, the model fit was perfect.

Hypothesis 2: Examining the intervening role of quality & quantity of sleep. Next, we tested a full mediation model by introducing poor sleep quality and sleep quantity as intervening variables between the need satisfaction composite and the two HRQOL outcomes. This model had the following fit, $\chi^2/df = 2.49$, CFI = .87, RMSEA = .13, SRMR =.07. Next, a partial mediation model was tested by adding direct paths between the need composite and the two outcomes. Although the relation between the need composite and global physical health was fully accounted

[2] CD4+ cell count was not significantly related to any of the assessed variables. One potential explanation for this null-relation was that there was little variation in the objective health condition of the studied sample. The majority of the sample was under stable antiretroviral therapy, had full virologic suppression and stable recovered cellular immunity. Thus their physical health status was fairly stable.

Table 1

Correlations between the study variables

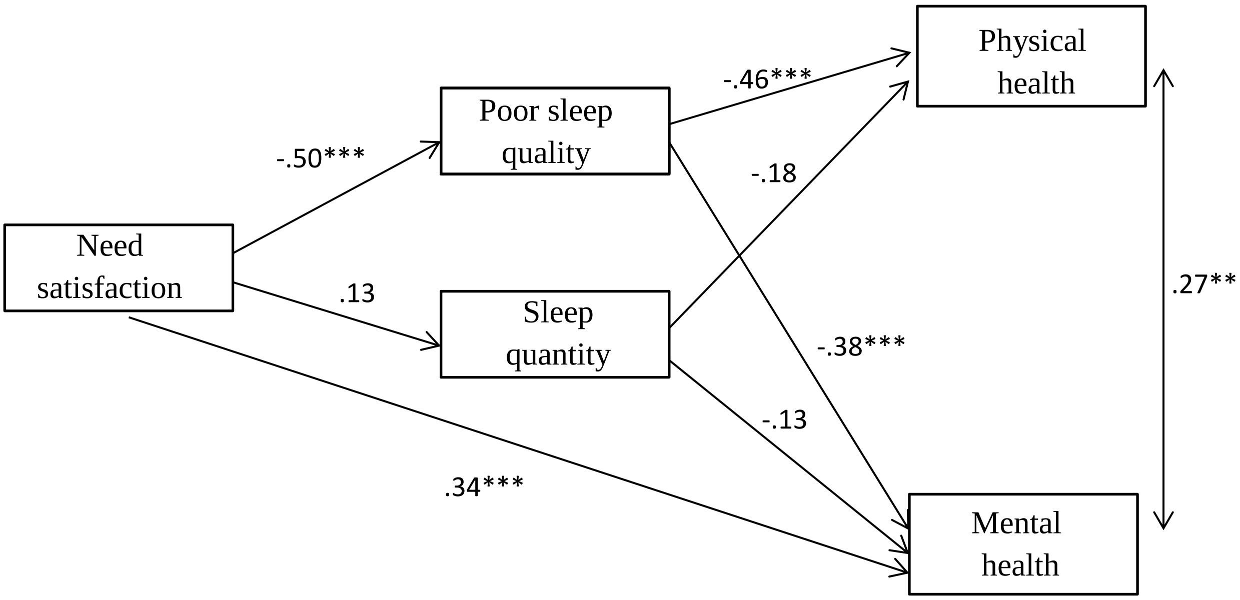
	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Autonomy	-												
2. Competence	.73**	-											
3. Relatedness	.69**	.65**	-										
4. Need composite	.92**	.89**	.87**	-									
5. Mindfulness	.61**	.52**	.52**	.62**	-								
Sleep Quality													
6. Poor sleep quality	-.38**	-.38**	-.38**	-.42**	-.24*	-							
7. Sleep latency	-.23*	-.23*	-.13	-.22*	-.21*	.48**	-						
8. Sleep disturbances	-.22*	-.30**	-.24*	-.28**	-.22	.39**	.27**	-					
9. Use of sleep medication	-.44**	-.39**	-.40**	-.46**	-.33**	.41**	.33**	.19	-				
Sleep Quantity													
10. Sleep duration	.13	.11	.24*	.18	.21*	-.45**	-.38**	-.19	-.39**	-			
11. Habitual sleep efficiency	.03	.09	.25*	.14	.00	-.37**	-.35**	-.12	-.26**	.64**	-		
HRQOL													
12. Global physical health	.31**	.24*	.33**	.33**	.38**	-.44**	-.25*	-.09	-.31**	.07	.09	-	
13. Global mental health	.52**	.46**	.42**	.53**	.38**	-.38**	-.32**	-.13	-.43**	.16	.08	.44**	-
Mean	3.48	3.70	3.98	3.72	4.32	1.17	1.25	1.19	.76	3.29	3.58	61.57	59.68
SD	.82	.74	.72	.68	.86	.74	.88	.47	1.21	.79	.85	21.29	19.17

Note. * p <.05, ** p<.01

for by quality of sleep, the need composite continued to yield a direct positive association with global mental health, which led to a significantly improved fit $\Delta\chi^2(1) = 11.67$, $p < .001$. The fit of the final partial mediation model was χ^2/df =1.48, CFI = .96, RMSEA =.07, SRMR =.06. This model is shown in Figure 1. The indirect association between the need composite and global physical ($\beta = .23$, $p < .01$; CI 95% [.12; .34]) and mental health ($\beta = .20$, $p < .01$; CI 95% [.10; .31]) via poor sleep quality was significant indicating that poor sleep quality fully mediated the relation with global physical health and partially mediated the relation with global mental health. In contrast, sleep quantity was unrelated to the need composite and global physical and mental health and thus failed to account for the association between need satisfaction and the two HRQOL outcomes.

Figure 1.

Need satisfaction predicting physical and mental health via quality and quantity of sleep.



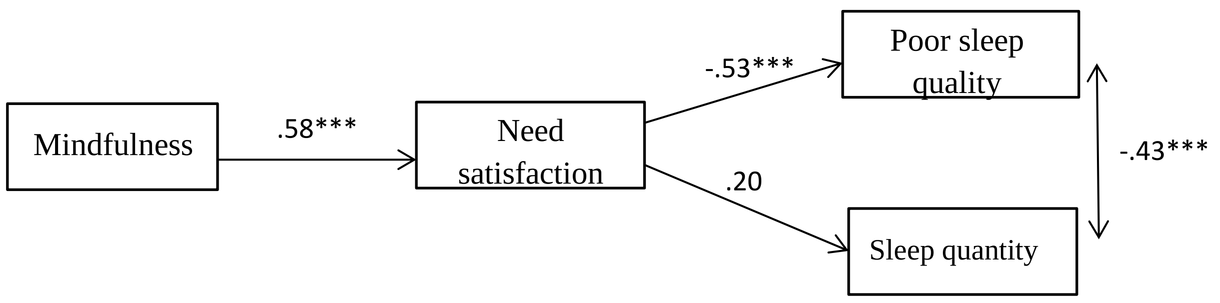
Note. *p<.05,**p < .01, p***<.001.

Hypothesis 3: Examining the mindfulness - sleep relation. A direct effect model was tested by adding paths from mindfulness to poor sleep quality and sleep quantity, which were allowed to correlate. The results indicated that mindfulness related negatively to poor sleep quality (β = -.35, p < .01) but was unrelated to sleep quantity (β = .12, *ns*). This model was fully saturated and thus had a perfect model fit.

Hypothesis 4: Examining the intervening role of need satisfaction. Next a full mediation model was tested by adding the need satisfaction composite as an intervening variable in the relation between mindfulness and the two sleep outcomes, resulting in the following fit, χ^2/df =1.49, CFI = .97, RMSEA =.07, SRMR =.05. Results from this model indicated that mindfulness related positively to the need composite and that the need composite in turn, was negatively related to poor sleep quality and unrelated to sleep quantity. We then tested a partial mediation model by adding direct paths between mindfulness and the two sleep outcomes. The fit of the partial mediation model was not significantly better than the full mediation model, $\Delta\chi^2(2)$ = .69, *ns*., indicating that the association between mindfulness and poor sleep quality was fully mediated by need satisfaction. This indirect association was significant (β = -.31, p < .001; CI 95% [-.41; -.21]). The final model is shown in Figure 2.

Figure 2.

Mindfulness predicting quality and quantity of sleep via need satisfaction.



Note. *p<.05,**p < .01, p***<.001.

Discussion

Although previous work grounded in SDT (Deci & Ryan, 2000; Vansteenkiste & Ryan, 2013) has focused on the role of need satisfaction in sleep (Campbell et al., 2015) and on psychological well-being among PLHIV (Igreja, Zuroff, Koestner & Saltaris, 2000), to the best of our knowledge the present cross-sectional study is the first to combine these two foci. That is, we examined the relation between the satisfaction of the psychological needs for autonomy, competence, and relatedness and PLHIV's HRQOL via their sleep. In addition, we investigated the role of mindfulness in contributing to the satisfaction of these basic psychological needs. Findings confirmed our hypotheses. Specifically, PLHIV who experienced higher need satisfaction also reported higher HRQOL which was largely explained through a negative relation with poor sleep quality. The findings further suggest that mindfulness facilitated higher psychological need satisfaction, which in turn contributed to better sleep quality. To the best of our knowledge the present study is the first to demonstrate such associations in PLHIV.

The finding that psychological need satisfaction relates to higher physical and mental health is consistent with previous research in non-clinical populations which showed need satisfaction to relate positively to indicators of well-being (Deci & Ryan, 2000) and testifies to the universal character of these needs by extending previous findings to PLHIV. Although previous studies examining the relation between psychological needs and well-being have tended to focus more exclusively on the relation with psychological well-being, the number of studies demonstrating relations with indicators of physical health is steadily increasing (e.g., Di Domenico & Fournier, 2014; Gonzalez, Swanson, Lynch & Williams, 2016; Ryan, Bernstein & Brown, 2010). The present results add to this body of work by providing further evidence that the benefits of psychological need satisfaction also extend to physical health, this time among PLHIV. Further, given that we controlled for CD4+ cell count in all of the models tested, the present results indicate that need satisfaction related to higher perceived physical health over and above an objective marker of health status. This finding is especially relevant for PLHIV given that their physical health, in particular, is compromised.

Interestingly, poor sleep quality, rather than sleep quantity, was uniquely associated with lower need satisfaction and lower mental and physical health and further accounted for the association between psychological need satisfaction and the two indicators of HRQOL. This finding is consistent with a previous study of university students which found sleep quality to be more strongly related to measures of physical and psychological health than sleep quantity (Pilcher, Douglas, & Sadowsky, 1997). The current sleep quality component is a multifaceted construct that includes sleep latency, number of nocturnal awakenings, use of sleep medication, as well as subjective appraisals of the quality of sleep. Thus, while sleep quantity simply constitutes total time asleep, sleep quality is more an indication of uninterrupted sleep that likely allows the individual to go through the various sleep stages that restore emotional and physical health. However, it should be noted that while poor sleep quality completely accounted for the relation between need satisfaction and physical health, it only partially accounted for the relation with mental health suggesting that sleep quality is only one pathway through which need satisfaction contributes to mental health and that other explanatory mechanisms should be considered. One other potential pathway is through the use of more adaptive emotion regulation styles such as emotional integration which is characterized by an openness to experiencing and exploring emotions (Roth et al., 2014). Indeed, one previous study indicated that maternal support for their adolescent child's need for autonomy predicted increases in adolescent self-esteem through increases in emotional integration one year later (Brenning, Soenens, Van Petegem & Vansteenkiste, 2015). However, more research is needed to explore emotion regulation styles as intervening processes in the relation between need satisfaction and a broader range of mental health outcomes.

The second global aim of the present study was to examine the role of mindfulness. Consistent with past work in a non-clinical sample (Campbell et al., 2015), a more mindful approach was related positively to psychological need satisfaction which, in turn, facilitated better sleep quality. Together, the present results imply that one way caregivers can help to improve the HRQOL of PLHIV is by helping them to cultivate mindfulness. This in turn is likely to aid their awareness of and receptivity to cues for psychological need satisfaction thereby also enabling better sleep quality. Encouragingly, there is evidence that mindfulness can be improved with meditation practice as evidenced by significant increases in dispositional mindfulness following mindfulness-based stress reduction (MBSR) interventions (e.g., Creswell, Irwin, Burklund et al., 2012). Moreover, previous studies examining the efficacy of MBSR interventions with PLHIV found participants to display improvements in both physical and psychological well-being post intervention (Cresswell, Myers, Cole, & Irwin, 2009; Gayner, Esplen, De Roche et al., 2012; Seyed Alinaghi, Jam, Foroughi et al., 2012). However, these studies did not consistently assess changes in mindfulness following the interventions, thus the underlying mechanisms accounting for these changes remain unclear. Indeed, the present results suggest that in addition to increasing mindfulness, MBSR may improve health outcomes through facilitating need satisfaction and better quality sleep.

The present study has a number of limitations. First, this study is cross-sectional, which prevents us from drawing any causal conclusions. For example, poor sleep quality may not only contribute to but may also stem from poor physical and mental health[3]. Future experimental or longitudinal research is needed to address this issue. Second, all of our primary measures were based on self-reports which can inflate the observed associations due to shared method variance. Future studies could overcome this problem by using objective sleep measures such as Polysomnography and actigraphy. Finally, our sample size was limited which prevented us from testing an integrative model with all of the assessed study variables. Further, our sample was fairly homogenous (e.g., predominantly male and Caucasian). Future research is needed to examine the generalizability of the present findings to the larger spectrum of PLHIV.

In sum, the present study underscores the role of basic psychological need satisfaction in determining the HRQOL of PLHIV. Specifically, the results indicate that HIV+ individuals who

---

[3] We also tested an alternative model in which paths were added from need satisfaction to mental and physical health and from mental and physical health to poor sleep quality and sleep quantity. Results indicated that need satisfaction related positively to physical health (β = .31, p < .01) and mental health (β = .52, p < .001) and that in turn, physical health (β = -.19, p < .05) and mental health (β = -.22, p < .05) were negatively related to poor sleep quality but unrelated to sleep quantity. Further, need satisfaction continued to yield a direct association with poor sleep quality (β = -.40, p < .001). However, comparison of the AIC fit indices indicated that the model testing need satisfaction predicting HRQOL via the sleep outcomes had a better fit (AIC = 1891.60) than the model testing need satisfaction predicting sleep via the HRQOL indicators (AIC = 2071.97).

feel volitional and effective in their behavior and close and connected to important others are likely to experience higher physical and mental health through better sleep quality. The results further suggest that dispositional mindfulness plays a role in facilitating need satisfaction and higher quality of sleep. Overall, the current findings provide initial evidence that healthcare professionals seeking to improve the HRQOL of PLHIV may focus on helping to develop a more mindful approach while also providing support for basic psychological needs.

References

Bravo, P., Edwards, A., Rollnick, S., & Elwyn, G. (2010). Tough decisions faced by people living with HIV: A literature review of psychosocial problems. *Aids reviews* 12:76-88.

Brenning, K., Soenens, B., Van Petegem, S., & Vansteenkiste, M. (2015) Perceived maternal autonomy support and early adolescent emotion regulation: a longitudinal study. *Review of social development* 24(3).

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology* 84: 822–848.

Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index – a new instrument for psychiatric practice and research. *Psychiatry Research* 28: 193–213.

Campbell, R., Vansteenkiste, M., Beyers, W., Mouratidis, A., Soenens, B., Verstraete, N., ...Vogelaers, D. Shifts in emerging adults' sleep pattern during an examination period: The role of basic psychological needs and stress**.** *Manuscript submitted for publication.*

Campbell, R., Vansteenkiste, M., Delesie, L.M., Mariman, A. N., Soenens, B., Tobback E., Van der Kaap-Deeder, J., & Vogelaers, D. P. (2015). Examining the role of psychological need satisfaction in sleep: A Self-Determination Theory perspective. *Personality and Individual Differences* 77: 199-204.

Centers for Disease Control and Prevention. Health-related quality of life. (2016). http.cdc.gov/hrqol/concept.htm. Accessed 12 Jan 2016.

Chen, B., Vansteenkiste, M., Beyers, W., Boone, L., Deci, E. L., Duriez, B. Lens, W., Matos, L., Mouratidis, A., Ryan, R. M., Sheldon, K. M., Soenens, B., Van Petegem, S., & Van der Kaap-Deeder, J., Verstuyf, J. (2015). Basic psychological need satisfaction, need frustration, and need strength across four cultures. *Motivation and Emotion* 39:216-236.

Costa, J., Pinto-Gouveia, J., Maroco, J. (2016). Chronic pain experience on depression and physical disability: The importance of acceptance and mindfulness-based processes in a sample with rheumatoid arthritis. *Journal of Health Psychology*.

Cresswell, J. D., Myers, H. F., Cole, S. W., & Irwin, M. R. (2009). Mindfulness meditation training effects on CD4+ T lymphocytes in HIV-1 infected adults: A small randomized controlled trial. *Brain, Behavior, and Immunity* 23:184–188.

Creswell, J. D., Irwin, M. R., Burklund, L. J., Lieberman, M. D., Arevalo, J. M. G., Ma, J., et al. (2012) Mindfulness-based stress reduction training reduces loneliness and pro-inflammatory gene expression in older adults: a small randomized trial. *Brain, Behavior, and Immunity*, 26:1095–1101.

Deci, E. L. & Ryan, R. M. (2000) The 'what' and 'why' of goal pursuits: Human needs and the self determination of behavior. *Psychological Inquiry*, 11:227-268.

Deci, E. L., Ryan, R. M., Gagné, M., Leone, D. R., Usunov, J., & Kornazheva, B. P. (2001) Need satisfaction, motivation, and well-being in the work organizations of a former Eastern Bloc country: A cross-cultural study of self-determination. *Personality and Social Psychology Bulletin*, 27:930–942.

Degroote, S., Vogelaers, D. P., Vermeir, P., Mariman, A., De Rick, A., Van Der Gucht, B., . . .Vandijck, D.M. (2013) Socio-economic, behavioural, (neuro)psychological and clinical determinants of quality of life (QoL) in people living with HIV: a pilot study. *Journal of the International AIDS Society*, 16(1)18643.

Di Domenico, S. I., & Fournier, M. A. (2014). Socioeconomic status, income inequality, and health complaints: A basic psychological needs perspective. *Social Indicators Research, 119*,1679-1697.

Gakhar, H., Kamali, A., & Holodniy, M. (2013) Health-related Quality of Life Assessment after Antiretroviral Therapy: A Review of the Literature. *Drugs*, 19:1398-1407.

Gayner, B., Esplen, M. J., DeRoche, P.,Wong, J., Bishop, S., Kavanagh, L., & Butler, K. (2012) A randomized controlled trial of mindfulness-based stress reduction to manage affective symptoms and improve quality of life in gay men living with HIV. *Journal of Behavioral Medicine*, 35(3):272–285.

Gillard, A., & Roark, M. F. (2013) Support for basic psychological needs in the context of HIV disclosure for older youth. *Children and Youth services,* 35: 102-111.

Holmbeck, G. N. (1997). Toward terminological, conceptual, and statistical clarity in the study of mediators and moderators: Examples from the child-clinical and pediatric psychology literatures. Journal of Counseling and Clinical Psychology, 65, 599-610.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling,* 6:1-55.

Igreja, I., Zuroff, D.C., Koestner, R., & Saltaris, C. (2000). Applying Self-Determination Theory to the prediction of distress and well-being in gay men with HIV and AIDS. *Journal of Applied Social Psychology*, *30*(4):686-706.

Kennedy, S., Goggin, K., & Nollen, N. (2004). Adherence to HIV medications: Utility of the theory of self-determination. *Cognitive Therapy and Research,* 28(5): 611– 629.

Kline, R. B. (2005) Principles and practice of structural equation modeling. New York: Guilford Press.

Lin, M. K., Wu, A. W., Revicki, D. A. (2002). Incorporating quality of life measures in HIV clinical trials. *HIV Clinical Trials*, 3(3):202-18.

Maynor, M.G., Swanson, D.P., Lynch, M., Williams, G.C. (2016). Testing satisfaction of basic psychological needs as a mediator of the relationship between socioeconomic status and physical and mental health. *Journal of Health Psychology*, *21*(6): 972-82.

Medley, A. M., Kennedy, C. E., Lunyolo, S., & Sweat, M. D. (2009). Disclosure outcomes, coping strategies, and life changes among women living with HIV in Uganda. *Qualitative Health Research*, 19(12): 1744–1754.

Moskowitz, J.T., Duncan, L.G., Moran, P.J., Acree, M., Epel, E.S., Kemeny, M.E., Hecht, F.M., & Folkman, S. (2015). Dispositional mindfulness in people with HIV: Associations with psychological and physical health. *Personality and Individual Differences*, 86: 88-93.

Oberjé, E. J. M., Dima, A.L., Van Hulzen, A.G.W., & Prins, J.M. (2015). Looking beyond health-related quality of life: Predictors of subjective well-being among people living with HIV in the Netherlands. *AIDS and Behavior*, 19:1398–1407.

O' Leary, K., O'Neill, S., & Dockray, S. J. (2016). A systematic review of the effects of mindfulness interventions on cortisol. *Journal of Health Psychology*, 21:2108-2121.

Peltzer, K. (2012). Health-related quality of life and antiretroviral therapy in Kwazlu-Natal South Africa. *Social Behavior and Personality*, 40(2):267-282.

Phillips, K. D., Mock K. S., Bopp C. M., et al. (2006). Spiritual well-being, sleep disturbance, and mental and physical health status in HIV-infected individuals. *Issues in Mental Health Nursing*, 27:125–39.

Phillips, K,.D., Sowell, R.L., Boyd, M., et al. (2005). Sleep quality and health-related quality of life in HIV-infected African-American women of childbearing age. *Quality of Life Resarch*,14:959–70.

Phillips, K.D., Sowell, R.L., Rojas, M., et al. (2004). Physiological and psychological correlates of fatigue in HIV disease. *Biological Research for Nursing*, 6:59–74.

Pilcher, J., Douglas, G., & Sadowsky, B. (1997). Sleep quality versus sleep quantity: relationships between sleep and measures of health, well-being and sleepiness in college students. *Journal of Psychosomatic Research*, 42(6):583-596.

Roth, G., Benita, M., Amrani, C., Shachar, B.H., Asoulin, H., Moed, A., Bibi, U., Kanat Maymon, Y. (2014). Integration of negative emotional experience versus suppression: Addressing the question of adaptive functioning. *Emotion*, 14(5):908-919.

Quinlivian, E. B., Messer, L. C., Adimora, A. A., Roytburd, K., Bowditch, N., Parnell, H., Seay, J., Bell, L., & Pierce, J. K. (2013). Experiences with HIV testing, entry, and engagement in care by HIV-infected women of color, and the need for autonomy, competency and relatedness. *Aids Patient Care*, 27(7):408-415.

Ryan, R. M., Bernstein, J.H., & Brown, K. W. (2010). Weekends, work, and well-being: psychological need satisfactions and day of the week effects on mood, vitality, and physical symptoms. *Journal of Social and Clinical Psychology, 29*(1):95-122.

Seyed Alinaghi, S., Jam, S., Foroughi, M., Imani, A., Mohraz, M., Djavid, G. E., & Black, D. S. (2012). Randomized controlled trial of mindfulness-based stress reduction delivered to human immunodeficiency virus-positive patients in Iran: Effects on CD4+ T lymphocyte count and medical and psychological symptoms. *Psychosomatic Medicine*, 74(6):620–627.

Uphold, C.R., Holmes, W., Reid, K., Findley, K., Parada, J.P. (2007). Healthy lifestyles and health-related quality of life among men living with HIV infection. *Journal of the Association of Nurses in AIDS care*, 18(6):54-66.

Vansteenkiste, M., & Ryan, R. M. (2013). On psychological growth and vulnerability: Basic psychological need satisfaction and need frustration as a unifying principle. *Journal of Psychotherapy Integration*, 23;263-280.

Ware, J.E., & Sherbourne, C.D. (1992). The MOS 36-item short-form health survey (SF-36).1. Conceptual framework and item selection. *Medical Care*, 30:473-83.

Wong, L. H., Van Rooyen, H., Modiba, P., Richter, L., Gray, G., McIntyre, J. A., et al. (2009). Test and tell: Correlates and consequences of testing and disclosure of HIV status in South Africa. *Journal of Acquired Immune Deficiency Syndromes*, 50(2): 215–222.

Wu, J., Wu, H., Lu, C., Gui, L., Pengsheng, L. (2015). Self-reported sleep disturbances in HIV-infected people: a meta-analysis of prevalence and moderators. *Sleep Medicine*, 16:901–907.

Xu, W., Oei, T. P. S., Liu, X., Wang, X., & Ding, C. (2016). The moderating and mediating roles of self-acceptance and tolerance to others in the relationship between mindfulness and subjective well-being. *Journal of Health Psychology*, 21:1446-1456.

Basic Psychological Need Experiences, Fatigue, and Sleep in Individuals with Unexplained Chronic Fatigue[1]

Grounded in Self-Determination Theory, this study tested the hypothesis that the satisfaction and frustration of the psychological needs for autonomy, competence, and relatedness, would relate to fatigue and subjective and objective sleep parameters, with stress and negative sleep cognitions playing an explanatory role in these associations. During a stay at a sleep laboratory in Belgium individuals with unexplained chronic fatigue (UCF; N = 160; Mage = 39.63 years, SD = 11.10; 78% female) underwent polysomnography and completed a questionnaire at three different points in time (i.e., after arrival in the sleep lab, before bed-time and the following morning) which assessed their need-based experiences and stress during the previous week, fatigue during the preceding day and negative sleep-related cognitions and sleep from the previous night, respectively. Results indicated that need frustration related to higher stress during the preceding week, which in turn related to higher evening fatigue. Need frustration also related to poorer subjective sleep quality and shorter sleep duration, as indicated by both subjective and objective shorter total sleep time and subjective (but not objective) longer sleep latency. These associations were accounted for by stress and negative sleep cognitions. Overall, these findings suggest that health-care professionals working with individuals with UCF may consider focusing on basic psychological needs within their therapeutic approach.

[1] Campbell, R*., Tobback, E*., Delesie, L., Vogelaers, D., Mariman, A., & Vansteenkiste, M. (2017) Basic psychological need experiences, fatigue and sleep in individuals with unexplained chronic fatigue. *Stress and health.* *Shared first authorship.

Introduction

Fatigue is a common complaint among the general population. As a subjective experience, it manifests through feelings of tiredness, weakness, or exhaustion (Shahid, Shen, & Shapiro, 2010). While fatigue is often attributed to a primary sleep disorder, psychiatric illness, or medical condition, in many individuals a definite cause cannot be determined. If such unexplained fatigue persists for more than six months, the term ‘chronic fatigue’ is used (Fukuda et al., 1994). Unexplained chronic fatigue (UCF) has been shown to co-occur with a broad range of conditions including depression, anxiety, and sleep disorders (Janssens, Zijlema, Joustra, Rosmalen, 2015; Mariman et al., 2013a). Between 87% and 95% of individuals with UCF report unrefreshing sleep despite adequate sleep duration (Mariman et al., 2013a; Mariman et al., 2013b). In light of this heterogeneity observed in individuals with UCF, there is a need to identify transdiagnostic predictors of fatigue and poor sleep among these individuals (e.g., Egan, Wade, & Shafran, 2011). In the present study we adopted a theory driven approach by considering psychological predictors of fatigue and sleep from an established psychological framework, namely Self-determination theory (SDT; Deci & Ryan, 2000).

Self-Determination Theory: Basic psychological needs

We adopted SDT as a framework for examining predictors of fatigue and sleep within individuals with UCF because it specifies three universal and inherent psychological needs which it claims are essential for well-being and optimal functioning: the need for *autonomy* refers to experiencing a sense of volition and self-endorsement in one’s activities, the need for *competence* involves feeling capable and effective in achieving desired outcomes and the need for *relatedness* reflects one‘s proclivity for strong interpersonal relationships (Deci & Ryan, 2000). According to SDT the satisfaction of these needs is critical for indivduals to flourish and experience psychological and physical well-being whereas the active frustration of these needs is said to elicit maladaptive or even pathological functioning. The notion of need frustration deserves attention in its own right because the mere absence of need satisfaction does not necessarily denote the presence of need frustration. Indeed, for psychological needs to be frustrated, a more active undermining or thwarting is required (Bartholomew, Ntoumanis, Ryan, Bosch, & Thogersen-Ntoumani, 2011; Vansteenkiste & Ryan, 2013). Autonomy frustration then involves feeling pressured to think feel or act a certain way, competence frustration refers to experiencing feelings of failure and inadequacy and relatedness frustration involves feeling excluded or socially isolated.

Previous research has extensively documented the association between psychological need satisfaction and adaptive outcomes such as higher well-being (e.g., life satisfaction & self-esteem; Deci & Ryan, 2000; Vansteenkiste & Ryan 2013), higher subjective energy (e.g., higher vitality; Ryan & Deci, 2008) and more salutary physical outcomes such as higher quality and quantity of sleep (Campbell, Vansteenkiste, Delesie, Mariman, et al., 2015). However, more recently research has increasingly begun to examine the costs associated with psychological need frustration. For example, studies have demonstrated that when psychological needs are frustrated individuals are more likely to report disordered eating behaviour (e.g., Verstuyf, Vansteenkiste, Soenens, Boone, & Mouratidis, 2013), depressive symptoms and exhaustion (e.g., Bartholomew et al., 2011). Together, these studies suggest that although low psychological need satisfaction has the potential to hinder individuals' growth and well-being, psychological need frustration can be especially harmful and uniquely predictive of ill-being (e.g., exhaustion and depressive symptoms) over and above a lack of need satisfaction (e.g., Bartholomew, et al., 2011; Chen et al., 2015).

Importantly, in addition to the claim that these psychological needs play a fundamental role in both adaptive and maladaptive functioning, SDT also conceives of these psychological needs as being universal. Specifically, SDT claims that these needs have the potential to either promote or impede human flourishing among all individuals regardless of their age, cultural background or even clinical status. A number of studies have provided support for this universality claim. For example, one recent study showed need satisfaction to relate positively to well-being (e.g., life satisfaction and vitality) and need frustration to relate positively to ill-being (e.g., depressive symptoms) across four diverse cultures (i.e. Belgium, China, Peru & the USA; Chen et al., 2015). Apart from being relevant across distinct cultures, the benefits of need satisfaction have also been shown to extend to clinical populations including adolescents with severe emotional and behavioural problems (e.g., Savard, Joussemet, Pelletier, & Mageau, 2013) and people living with HIV (Campbell, Vansteenkiste, Delesie, Soenens, et al., 2016). However, despite previous findings demonstrating that psychological need-based experiences relate to subjective energy and sleep, research is yet to examine whether these previously identified associations generalize to individuals with UCF.

Previous research provides some indirect evidence for the hypothesized role of need-based experiences in the fatigue and poor sleep in individuals with UCF. For example, substantial occupational disability occurs in individuals with UCF which likely thwarts psychological needs. Up to 50% of individuals with UCF report being unemployed and of those who remain employed, many have to change jobs, work fewer hours and receive less pay due to their illness (Assefi, Coy, Uslan, Smith, & Buchwald, 2003). This inability to work may engender competence and autonomy frustration as these individuals likely feel unable to carry out valued everyday activities (i.e., going to work) and feel pressured by their condition to either not work or work less. Further, previous findings indicate that individuals with work disability (i.e., who work less than 50% and receive disability pension) report poorer sleep quality than those who return to work after long-term sick leave (Oyeflaten et al., 2014). In addition to occupational disability, individuals with UCF often report social isolation and lack of social support from family and friends (Drachler et al., 2009), which is indicative of the frustration of their need for relatedness. The long search for a diagnosis often results in individuals feeling frightened, angry and alone. With no explanation for their condition, individuals with UCF often experience disbelief and a lack of empathy from their direct environment (Drachler et al., 2009). Support and understanding from family and friends is, however, considered vital and lack of social support has been identified as a perpetuating factor of fatigue severity and functional impairment (Prins et al., 2004). Although these previous studies among UCF populations did not directly assess basic psychological needs using SDT-based measures, they provide some indirect evidence for the hypothesized association between need-based experiences and fatigue and sleep within this clinical group.

Intervening mechanisms: Symptoms of stress and negative sleep cognitions

In light of the evidence suggesting that need-based experiences may relate to fatigue and sleep in individuals with UCF, the question arises as to which explanatory processes may account for these hypothesized associations. In the present study, we propose that symptoms of stress, such as nervous arousal, difficulty relaxing, agitation and irritability (Lovibond & Lovibond, 2004), and negative sleep-related thoughts (e.g., ruminating about the consequences of not getting enough sleep), are likely to play an intervening role in the hypothesized association between need satisfaction- and frustration and fatigue and sleep. We propose symptoms of stress and negative sleep-related cognitions as potential explanatory processes because need frustration has previously been shown to engender both stress (e.g., Campbell, Vansteenkiste, Delesie, Soenens, et al al., 2016; Weinstein & Ryan, 2011) and dysfunctional cognitions like worrying and rumination (Van der Kaap-Deeder, Vansteenkiste, Van Petegem, Raes, & Soenens, 2016).

Moreover, previous research has extensively documented associations between both stress (e.g., Valerio, Kim, & Sexton-Radek, 2016) and negative sleep cognitions (e.g., Wood, Joseph, Lloyd, & Atkins, 2009) and poorer sleep outcomes. Indeed, a recent prospective 6-day diary study in 27 individuals with chronic fatigue syndrome (CFS)[2] showed that somatic arousal and negative pre-sleep cognitions predicted poorer subjective sleep quality and poorer subjective sleep efficiency. Much like symptoms of stress, somatic arousal which is referred to as the experience of a jittery, nervous feeling in the body, was found to predict perceiving sleep to be unrefreshing, a common complaint among individuals with UCF (Russell, Wearden, Fairclough, Emsley, & Kyle, 2016).

Although the root of these pre-sleep arousals was not examined, we propose that they may at least be partly grounded in need frustration. For example, need frustration resulting from being unable to work and feeling socially excluded is likely to give rise to symptoms of stress (e.g., tension and over-arousal). During the day these symptoms of stress are likely to erode energy levels

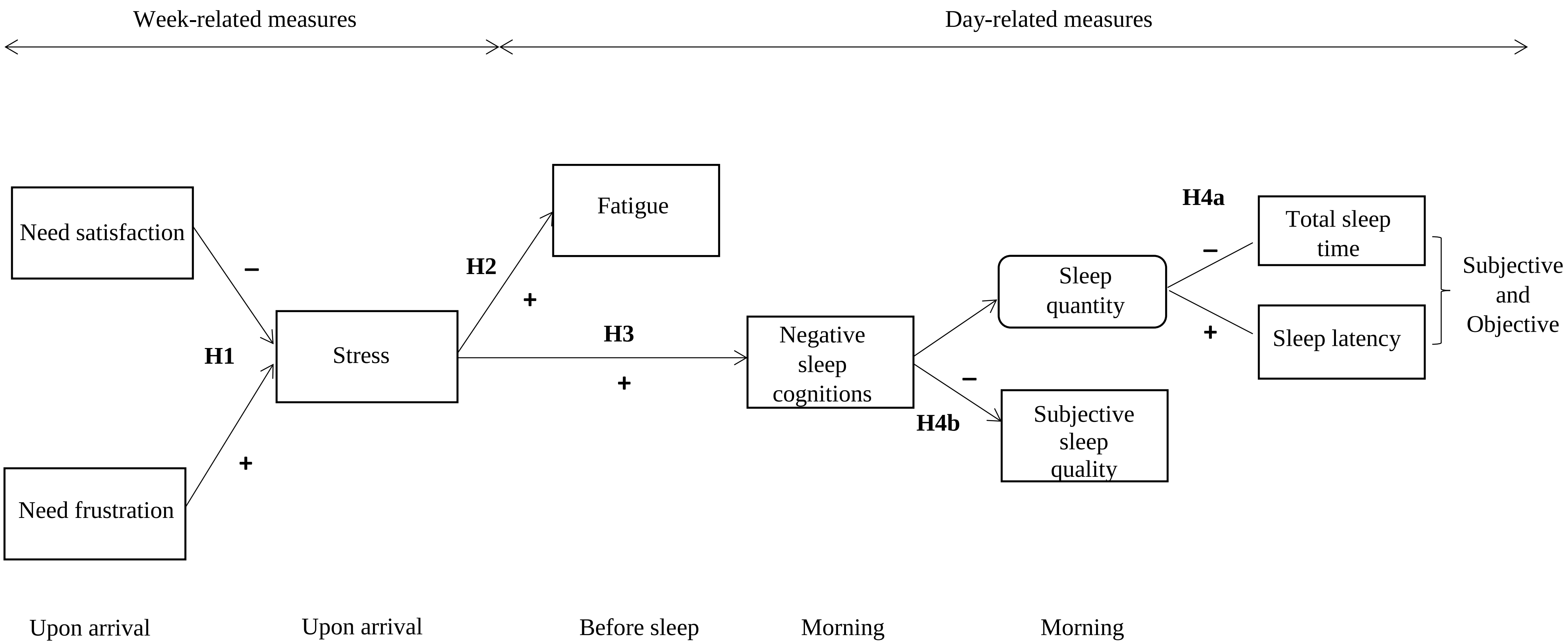
[2] Chronic Fatigue Syndrome is diagnosed through multidisciplinary assessment by a medical professional usually according to the Fukuda et al., criteria (1994). While individuals with UCF in the present study had complaints of fatigue for a minimum of 6 months, they had not yet undergone multidisciplinary assessment to receive a clinical diagnosis.

thereby engendering fatigue, whereas at night symptoms of stress may feed into negative cognitions when trying to fall asleep which in turn may negatively impact on quality and quantity of sleep. In line with this, a short-term longitudinal study among university students showed that increases in psychological need frustration related to increases in daytime dysfunction and poor sleep quality and reductions in sleep quantity through (i.e., accounted for by) increases in stress, suggesting that stress represents a critical explanatory mechanism (Campbell, Vansteenkiste, Soenens, & Beyers, 2016). Furthermore, Lopez et al. (2011) found that individuals with CFS who followed a group-based cognitive behavioural stress management intervention reported significant decreases in perceived stress and improvements in fatigue and unrefreshing sleep compared to baseline and compared to individuals who received psycho-education. This intervention may have reduced stress through increasing patient's basic psychological need satisfaction as it focused on modifying individuals' outlook, coping strategies and improvement of social support perceptions. However, the intervening role of both stress and negative sleep cognitions in the relation between psychological need frustration and fatigue and sleep in individuals with UCF has not yet been examined.

Present study

The global objective of the present cross-sectional study was to test an integrative model in a large sample of individuals referred to a tertiary care centre for investigation of UCF. As shown in Figure 1, we examined the relation between psychological need experiences (i.e., their satisfaction and frustration) and both fatigue and quality and quantity of sleep, while considering the explanatory role of stress and negative sleep cognitions in these associations. Indeed, theoretical models of insomnia and previous empirical studies have consistently argued and found evidence for the role of stress in contributing to negative pre-sleep cognitions which in turn have been shown to relate to poorer sleep outcomes (e.g., Espie, Broomfield, MacMahon, Macphee, & Taylor, 2006; Morin, Rodrigue, & Ivers, 2003). Hence, we sought to investigate whether stress and negative

Figure 1. The hypothesized model



Note. H = hypothesis

cognitions would play a similar role among UCF patients by examining their intervening role in the relation between need-based experiences and the fatigue and sleep outcomes.

This study builds on previous research in three significant ways. First, by investigating whether the previously identified association between psychological need experiences and fatigue and sleep within a non-clinical population (i.e., Campbell, Vansteenkiste, Delesie, Mariman, et al., 2015) extends to the clinical population of UCF. Second, we sought to account for the process underlying this association, thereby examining both stress and negative sleep cognitions as intervening mechanisms in the relation between basic psychological needs, fatigue and the sleep outcomes. Finally, we assessed a variety of sleep outcomes (i.e., sleep latency, total sleep time, wake after sleep onset) not only subjectively but also objectively using sleep parameters derived from polysomnography (PSG). This allowed us to avoid the well-known problem of shared method variance in case of the use of a single informant. To further reduce the bias of shared method variance, we assessed the study variables at different points in time. It seemed especially critical to circumvent the issue of shared method variance in the present sample because previous research suggests that individuals with UCF are likely to have a biased perception of their sleep, as is evidenced by moderate correlations between their self-reported and objectively recorded sleep (e.g., Creti et al., 2010). This biased perception is perhaps because individuals with UCF may attribute their fatigue to perceived deficits in their sleep. As a result, their fatigue may cause them to become increasingly attentive to and biased towards their sleep, potentially leading to the observed discrepancies between subjective and objective sleep measures.

Although we assessed both need-satisfying and need-frustrating experiences, congruent with past work (Bartholomew et al., 2011; Van der Kaap-Deeder, Vansteenkiste, Soenens, & Mabbe, 2016) and theorizing (Vansteenkiste & Ryan, 2013), we expected higher psychological need frustration, rather than low need satisfaction, to be especially related to higher stress (Hypothesis 1). In turn, we expected stress to be positively related to both fatigue (Hypothesis 2) and negative sleep cognitions (Hypothesis 3). Finally, we expected that negative sleep cognitions in turn would relate to poorer sleep quality (Hypothesis 4a) and to reduced sleep quantity (Hypothesis 4b), as indexed by reduced total sleep time, higher sleep latency and more frequent awakenings after sleep onset.

Methods

Participants and procedure

All participants were recruited between July 2015 and March 2016 at time of referral to the tertiary care center for further clinical investigation of UCF at Ghent University Hospital. The major presenting complaint was severe chronic fatigue with a negative impact on daytime functioning, for which no apparent explanation could be found by conventional medical evaluation in primary and/or secondary care settings. All participants had complaints of UCF for a minimum of 6 months before being referred to the centre. Assessment of UCF at the centre involves internal medical assessment, psychodiagnostic screening, rehabilitation assessment and polysomnography combined with a multiple sleep latency test (MSLT).

Participants were eligible for inclusion if their chronic fatigue had persisted for longer than six months, if they were at least 18 years old and Dutch-speaking. Upon recruitment participants were informed that they would be required to complete three online questionnaires during their stay at the sleep laboratory for diagnostic polysomnography. The first questionnaire was completed soon after arrival in the sleep lab and assessed their psychological functioning during the preceding week (i..e., psychological need satisfaction and stress; *Time 1*). The second questionnaire was completed just before bedtime and assessed fatigue during the preceding day (i.e., *Time 2*). The third questionnaire was completed upon awakening the following morning and assessed subjective sleep outcomes from the preceding night (*i.e., Time 3*). The questionnaires were completed on laptops provided in the sleep lab. Paper versions were also made available for participants who preferred to complete a hardcopy version. Signed informed consent was provided by all participants and the study was approved by the institutional Ethical review Board of the University Hospital Ghent, Belgium.

The final sample consisted of 160 adults (78.1% female; *M*age = 39.63 years, SD = 11.10). Of the 160 participants, 135 (85.38%) completed all three self-report assessments. Little's MCAR was non-significant [χ^2 (55) = 68.99, p >.05] indicating that the data were likely to be missing at random. As a result, Full Information Maximum Likelihood (FIML) was used to handle missing data in SEM (Little & Rubin, 1987). Following multidisciplinary assessment of UCF at the center participants received the following diagnoses: 17 (10.6%) CFS without comorbidity, 14 (8.7%) CFS with comorbidity, 13 (8.1%) primary sleep disorder 13 (8.1%), 40 (24.8%) psychiatric disorder, 23 (14.3%) combination of psychiatric and sleep disorder and 16 (3.7%) burn-out. Thirty-eight participants (23.6%) were categorized as "other", which meant that their diagnosis either did not fall into one of the above categories or that their diagnosis was still unknown after multidisciplinary assessment. Fifty-one (31.9%) participants reported being single and 109 (68.1%) participants were either married or co-habiting. Seven participants (4.3%) had completed a primary education, 88 (55%) had completed secondary education and 64 (40%) had completed a higher form of education. Fifty-seven percent of the sample reported depressive symptoms but were not diagnosed as having a depressive disorder and 93 (58%) participants were unemployed at the time of their participation in the study.

Measures

Time 1 - after arrival at the sleep lab.

Basic psychological need satisfaction and need frustration scale (BPNSNFS). The satisfaction and frustration of basic psychological needs was assessed using the BPNSNFS (Chen et al., 2015). Participants rated whether they felt their needs for autonomy (e.g., "I felt that my choices reflected who I really am" or "I felt forced to do many things that I didn't choose to do"), competence (e.g., "I felt confident that I could do things well" or "I had serious doubts about whether I could do things well") and relatedness (e.g. "I felt connected with people who care for me and whom I care for" or "I felt excluded from the group that I want to belong to") were satisfied or frustrated during the previous week on a 5-point scale ranging from 1 (*Not at all true*) to 5 (*Very* *true*). The scale consists of 24 items, 8 items per need, 4 of which tap into need satisfaction and the 4 of which tap into need frustration. A CFA with robust maximum likelihood estimation was performed to evaluate the fit of a 6-factor model which differentiated between the satisfaction and frustration of each of the three needs. The lower order CFA with the 4 satisfaction and 4 frustration items loading onto the satisfaction and frustration of the corresponding need yielded a good fit, X^2/df= 1.52, CFI= .93, SRMR= .07, RMSEA= .06. The factor loadings of all items were satisfactory and ranged between .66 and .87. The higher order CFA with the three need satisfactions and three need frustrations loading onto a need satisfaction and need frustration composite also had a good fit, X^2/df= 1.54, CFI= .92, SRMR= .07, RMSEA= .06, with a minimum loading of .58. Two composite scores were created by averaging the 12 items which assessed need satisfaction (α = .87) and the 12 items which assessed need frustration (α = .88).

Stress. Symptoms of stress were assessed using the stress subscale from the short-form version of the Depression Anxiety and Stress Scale (DASS; Lovibond & Lovibond, 2004). The subscale consists of 7 items which measure symptoms of stress (e.g., “I tended to over-react to situations”, “I felt that I was using a lot of nervous energy”, & “I found myself getting agitated”) during the past week. The items were rated on a 4-point scale, ranging from 0 (*Not applicable at all*) to 3 (*Very much so*). Cronbach’s alpha in this sample was .91. This 7 item stress subscale has been shown to have good internal consistency in non-clinical (e.g., Henry & Crawford, 2005 & Willemsen, Markey, Declercq & Vanheule, 2011) and clinical samples (e.g., Antony, Bieling, Cox, Enns, & Swinson 1998). Previous studies have demonstrated this scale to be related to a variety of variables in the expected directions, underscoring it’s the construct validity. Specifically, it has been shown to be positively related to anxiety, depression and negative affect and negatively related to positive affect (Crawford & Henry, 2003; Henry & Crawford, 2005). Furthermore, it has also been linked to poorer emotional self-regulation and lower mindfulness (Lyvers, Makin, Toms, Thorberg, & Samios, 2014)

Time 2 – before bedtime.

Fatigue. Symptoms of fatigue were assessed using the lassitude subscale from the Inventory of Depression and Anxiety Symptoms (IDAS; Watson et al., 2007). The subscale consists of 6 items which were adapted so that they assessed symptoms of fatigue during the past day (e.g., "Today I felt exhausted"). Items were answered on a 5-point scale ranging from 1 (*Not at all*) to 5 (*Very much so*). Cronbach's alpha was .81.

Time 3– upon awakening the following morning.

Negative sleep cognitions. Negative sleep cognitions whilst trying to fall asleep or get back to sleep were measured in the morning using the 5 negative sleep-related items (e.g., "If I don't get to sleep soon, I will feel very tired tomorrow") from the Self-Statement Test: 60+ (SST:60+) (Fichten et al., 1998). The items were rated on a 5-point scale ranging from 1 (*Not applicable at all*) to 5 (*Very much so*). Cronbach's alpha was .76.

Subjective total sleep time. Subjective total sleep time was calculated from four open ended questions from the Pittsburgh Sleep Diary (Monk et al., 1994) which were completed in the morning. Specifically, total sleep time was calculated from items assessing bedtime, the number of minutes it took to fall asleep (i.e., sleep latency), the number of minutes spent awake during the night after initially falling asleep (i.e., wake after sleep onset) and the final wake time. First, total time in bed was calculated using the bedtime and the final wake time. Next, the total sleep time was calculated by subtracting sleep latency and wake after sleep onset from the total time in bed.

Subjective sleep quality. Subjective sleep quality was also measured in the morning using two visual analogue scales (VAS) which assessed the quality of the previous night's sleep (i.e., "How was the quality of your sleep last night?") and whether the previous night's sleep was experienced as restorative (i.e., "How restorative was your sleep?"). Both VAS's were rated on a score from 0 (i.e., "*Very bad"* or "*Not at all restorative"*) to 100 (i.e., "*Very good" or* "*Completely restorative"*). A composite score of subjective sleep quality was created by averaging the scores on these two VAS scales ($\alpha = .73$).

Objective sleep parameters. Objective sleep parameters were assessed by Polysomnography (PSG). PSG was recorded and manually scored in 30-second epochs by an experienced PSG technologist, according to the 2007 scoring manual of the American Academy of Sleep Medicine (AASM) (Iber et al., 2007). Sleep parameters derived from PSG included *total sleep time*, which gives an objective indication of the total time in minutes that each participant was actually asleep, *sleep latency* which provides an objective measure of the number of minutes it took each participant to fall sleep after going to bed and *wake after sleep onset* which provides an objective indication of the number of minutes that each participant spent awake throughout the night after initially falling asleep.

Statistical Analyses

To examine the intervening role of stress and negative sleep cognitions in the relation between basic psychological needs, fatigue and subjective and objective sleep outcomes path models were tested (with manifest variables) using Mplus7. Model fit was assessed using the χ^2 test, the comparative fit index (CFI), the standardized root mean square residual (SRMR), and the root mean square error of approximation (RMSEA). An acceptable fit was indicated by χ^2/df ratio of 2 or below, CFI values of .90 or above, and SRMR and RMSEA values of around .08 or below (Hu & Bentler, 1999; Kline, 2005). After inspection of the relation between patients' characteristics and the study variables two variables (i.e., number of comorbidities and age) were controlled for in the integrated models (see preliminary analysis). In testing the role of basic psychological needs we followed a stepwise procedure by first testing the unique contribution of a composite score of need satisfaction and need frustration and then breaking down the composite score into its subcomponents so as to examine the unique contribution of the three separate needs (i.e., for autonomy, competence and relatedness). In each step two models were tested, one which examined relations with the subjective sleep outcomes and one which examined relations with the objective sleep outcomes. In all models the intervening role of stress and negative sleep cognitions was examined by tests of indirect effects (MacKinnon, Lockwood, & Williams). These indirect effects were tested using bootstrapping (1000 draws) to account for potential deviations from multivariate normality.

Results

Preliminary Analyses

Background characteristics. The relation between the participants' background characteristics and the study variables was examined using a MANCOVA with gender, education level and employment status as fixed factors, age and number of comorbidities as co-variates and all study variables as dependent variables. Although none of these background variables yielded a significant multivariate effect, subsequent univariate ANOVAS revealed several significant relations between the background characteristics and the study variables. Age was negatively related to objective total sleep time [F (1, 95) = 12.02, p < .001, η^2 = .11] and positively related to objective wake after sleep onset [F (1, 95) = 11.29, p < .001, η^2 = .11]. Number of comorbidities was positively related to objective [F (1, 95) = 5.79, p < .05, η^2 = .06] and subjective [F (1, 95) = 8.02, p < .01, η^2 = .08] wake after sleep onset, objective [F (1, 95) = 9.38, p < .01, η^2 = .09] and subjective [F (1, 95) = 6.50, p < .05, η^2 = .06] sleep latency, and negatively related to objective[F (1, 95) = 9.02, p < .01, η^2 = .09] and subjective [F (1, 95) = 7.78, p < .01, η^2 = .08] total sleep time and subjective sleep quality [F (1, 95) = 5.05, p < .05, η^2 = .05]. These significant relations between age and number of comorbidities (i.e., none, one, or two) and the study variables were controlled for in the subsequent integrative models.

Descriptive statistics and correlations. The means, standard deviations and correlations between all the study variables are shown in Table 1. Need satisfaction and need frustration were related to stress, fatigue and negative sleep cognitions in the expected directions but were unrelated to the subjective and objective sleep parameters. Stress was positively related to fatigue and negative sleep cognitions and was negatively related to subjective sleep quality but unrelated to the other sleep parameters. Negative sleep cognitions were related to the four subjective sleep indicators in the expected directions but were unrelated to the three objective sleep parameters. Finally, subjective

Table 1.

Correlations between all study variables

Variables (Units)	1	2	3	4	5	6	7	8	9	10	11	12
1. Need satisfaction (1-5)	-											
2. Need frustration (1-5)	-.73**	-										
3. Stress (0-3)	-.43**	.56**	-									
4. Fatigue (1- 5)	-.19*	.21**	.24**	-								
5. Negative sleep cognitions (1–5)	-.22*	.25**	.34**	.13	-							
6. Subjective sleep quality (1 – 100)	.15	-.16	-.20*	-.20*	-.27**	-						
7. Subjective total sleep time (min)	.07	-.03	.02	.07	-.21*	.16	-					
8. Subjective sleep latency (min)	-.13	.04	-.04	-.14	.28**	-.27**	-.49**	-				
9. Subjective WASO (min)	-.06	.02	-.02	-.05	.20*	-.25**	-.74**	.49**	-			
10. Objective total sleep time (min)	.00	.08	.01	.10	-.14	.08	.42**	-.45**	-.52**	-		
11. Objective sleep latency (min)	-.15	.04	-.06	-.02	.08	-.10	-.25**	.43**	.31**	-.42**	-	
12. Objective WASO (min)	.03	-.09	-.00	-.10	.12	-.10	-.40**	.32**	.46**	-.96**	.27**	-
Mean	3.64	2.34	.94	3.17	2.29	40.30	389.79	39.65	37.03	374.90	28.82	81.95
SD	.64	.72	.70	.80	.84	20.58	119.70	39.13	55.56	61.66	27.41	50.83

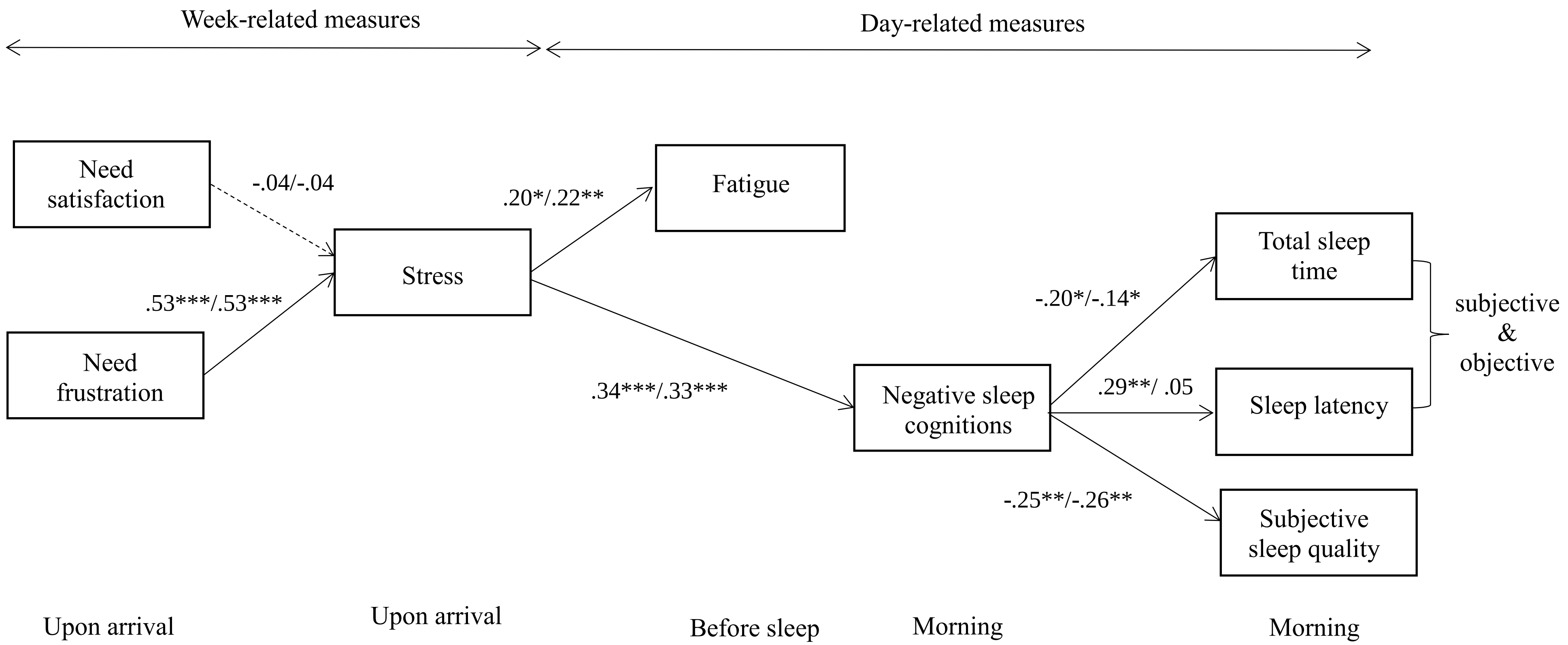
Note. *p<.05,**p < .01

total sleep time, sleep latency and wake after sleep onset were moderately correlated with their respective objective indicators. Paired sample *t*-tests indicated that the mean difference between subjective and objective total sleep time was not significant [$t(133) = 1.65$, *ns*] whereas the mean difference in subjective and objective sleep latency [$t(124) = 2.79$, $p<.01$] and wake after sleep onset was significant [$t(110) = -7.86$, $p<.001$], yet in the opposite direction. Participants overestimated their sleep latency by 9.31 minutes and underestimated their wake after sleep onset by 40.82 minutes on average.

Preliminary Analyses

Testing the proposed model. In line with the timing of the assessment of the different concepts, an integrated model was tested in which paths were added from the need composite variables (i.e., need satisfaction and need frustration) to stress, from stress to fatigue and negative sleep cognitions and lastly, from negative sleep cognitions to the subjective sleep outcomes (i.e., subjective total sleep time, subjective sleep latency and subjective sleep quality), which were allowed to correlate. The final model, $X^2(17) = 16.42$, $p = .49$, $X^2/df = .97$, CFI = 1.00, SRMR = .05, RMSEA = .00, is shown in Figure 2 (see the first coefficients reported). Results indicated that need frustration was uniquely positively related to stress, which in turn, was positively related to fatigue and negative sleep cognitions. Negative sleep cognitions were, in turn, negatively related to subjective total sleep time and subjective sleep quality and positively related to subjective sleep latency. Next, direct paths were gradually added in between the predictor and outcome variables that were significantly related (see Table 1). Specifically, direct paths were added between the two need composite scores and fatigue and negative sleep cognitions and between stress and subjective sleep quality. However, these paths were removed from the model because they did not lead to an improved model fit. The indirect association between need frustration and fatigue via stress was significant ($\beta = .11$, $p < .05$; CI 95% [.023; .187]). Further, the indirect association between need frustration and subjective sleep quality ($\beta = -.04$, $p < .05$; CI 95% [-.082; -.009]), subjective total sleep time ($\beta = -.04$, $p < .05$; CI 95% [-.061; -.010]) and subjective sleep latency ($\beta = .05$, $p <.01$; CI 95% [.020; .083]) via stress and negative sleep cognitions was also significant. These results

Figure 2. Psychological need experiences predicting fatigue and subjective and objective sleep outcomes via stress and negative sleep cognitions



Note. *p<.05,**p < .01, p***<.001
The first coefficients reported are the results from the model including only the subjective sleep outcomes. The second coefficient reported are the results from the model including only the objective sleep outcomes.

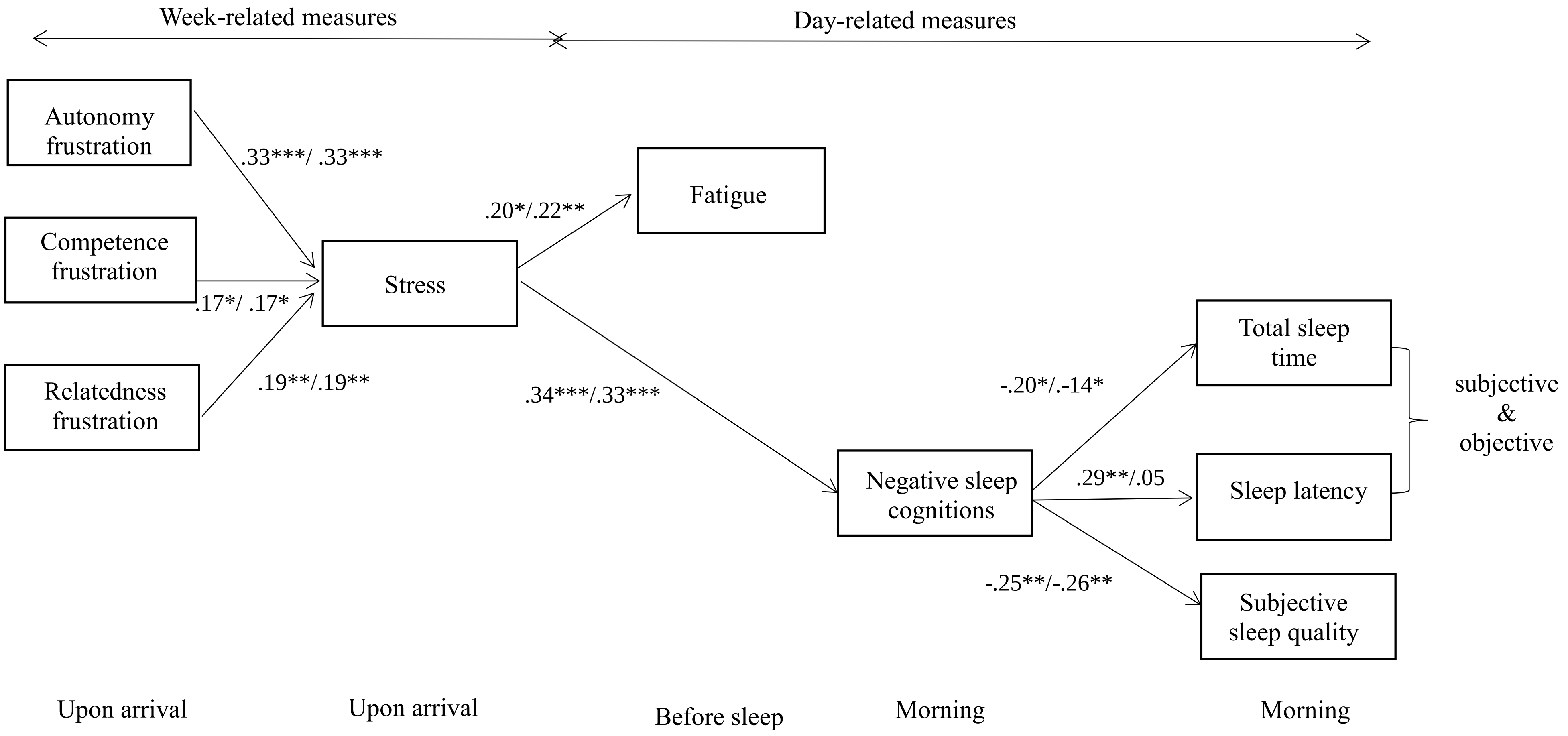
indicated that stress completely accounted for the association between need frustration and fatigue, whereas need frustration had an indirect association with subjective quality and quantity of sleep through (i.e., accounted for by) stress and negative sleep cognitions.

Next, in a second model subjective total sleep time and subjective sleep latency were replaced by their respective objective indicators derived from polysomnography. Similar to the first model, all dependent variables (i.e., objective total sleep time, objective sleep latency and subjective sleep quality) were allowed to correlate. The final model, $X^2(22) = 27.30$, $p = .20$, $X^2/df = 1.24$, CFI = .97, SRMR = .05, RMSEA = .04, is shown in Figure 2 (see the second coefficients reported in the figure). The results of this model were similar to the first model with one exception, namely the relation between negative sleep cognitions and objective sleep latency which was non-significant. Again, direct paths were gradually added in between the predictor and outcome variables that were significantly related (see Table 1). Similar to the previous model, direct paths were added between the two need composite scores and fatigue and negative sleep cognitions and between stress and subjective sleep quality. However, these paths were dropped from the model because they did not lead to an improved model fit. Similar to the first model tested, all indirect associations between need frustration and the outcomes were significant (range CI 95% [-.082; .199], apart from the indirect association between need frustration and objective sleep latency via stress and negative sleep cognitions ($\beta = .01$, *ns*).

Because objective total sleep time and objective wake after sleep onset were highly correlated ($r = -.96$, $p < .01$) we could not include them simultaneously in the same model as dependent variables. For this reason, we opted not to include wake after sleep onset in the final integrative models. Instead, we tested two models (i.e., one including only subjective sleep outcomes and one including only objective sleep outcomes) in which we examined the relation between the psychological predictors and wake after sleep onset. Specifically, in the model including only the subjective sleep outcomes we replaced subjective total sleep time with subjective wake after sleep onset and in the model including only objective sleep outcomes we replaced objective total sleep time with objective wake after sleep onset. These models produced similar results to the previous models and indicated that negative sleep cognitions were significantly related to higher subjective wake after sleep onset (β = .17, p < .05) but were unrelated to objective wake after sleep onset (β = .10, *ns*). In both of these models the indirect association between needfrustration and subjective wake after sleep onset (β = .03, *ns*) and between need frustration and objective wake after sleep onset (β = .02, *ns*), was not significant.

Finally, we examined the unique role of the three individual need frustrations (i.e., autonomy, competence and relatedness frustration) in the prediction of the outcomes in the main integrative model. The results of the model including the subjective, $X^2(22) = 23.01$, p = .40, $X^2/df = 1.05$, CFI = .99, SRMR = .05, RMSEA= .02, and objective, $X^2(27) = 31.29$, p = .26, $X^2/df = 1.16$, CFI = .97, SRMR =.05, RMSEA=.03, sleep outcomes revealed that each of the individual need frustrations were uniquely and positively related to stress. All of the other relations between the study variables were similar to the previous models (see Figure 3). The indirect association between autonomy frustration and fatigue (β = .07, p <.05; CI 95% [.009; .121]) via stress was significant as well as the indirect association between autonomy frustration and subjective sleep quality (β = -.03, p <.05; CI 95% [-.053; -.004]), subjective total sleep time (β = -.02, p <.05; CI 95% [-.039; -.005]), and subjective sleep latency (β = .03, p <.05; CI 95% [.010; .050]) via stress and negative sleep cognitions. Further the indirect association between relatedness frustration (β = .02, p <.05; CI 95% [.002; .035]) and subjective sleep latency via stress and negative sleep cognitions was also significant. All other indirect associations between competence and relatedness frustration and the outcomes did not reach significance.

Figure 3. Autonomy, competence and relatedness frustration predicting fatigue and subjective and objective sleep outcomes via stress and negative sleep cognitions



Note. *p<.05,**p < .01, p***<.001
The first coefficients reported are the results from the model including only the subjective sleep outcomes. The second coefficient reported are the results from the model including only the objective sleep outcomes.

Discussion

The present study examined whether the satisfaction and frustration of the basic psychological needs for autonomy, competence and relatedness, as conceived within SDT, would relate to fatigue and sleep through (i.e., accounted for by) stress and negative sleep cognitions in a large sample of individuals referred with UCF. The fact that these individuals, who reported unexplained complaints of fatigue for more than six months, underwent a PSG to shed light on their condition, created an ideal opportunity to follow them closely during a 24-hour period. This made it possible to conduct multiple self-report assessments and to examine the associations between the study variables and both subjective and objective sleep parameters. Several interesting findings emerged.

An Integrative Model

Overall, the findings revealed that the participants who experienced frustration of their psychological needs during the past week reported higher evening fatigue. Perceived stress fully accounted for this association. Psychological need frustration also contributed to poorer subjective sleep quality and shorter sleep duration, as indicated by both subjective and objectively assessed total sleep time and subjective sleep latency. These relations could be explained by the combined presence of higher stress and negative sleep cognitions, which played an intervening role in the need-sleep outcome association. Overall, the findings underscore the critical role of experiences of need frustration (Bartholomew et al., 2011; Vansteenkiste & Ryan, 2013). Indeed, it appeared that it was not so much a lack of need fulfilment, but rather the more active frustration of individuals' psychological needs that was related to higher symptoms of stress and the associated maladaptive pattern of fatigue and poor sleep.

The finding that stress accounted for the association between need frustration and evening fatigue is consistent with recent findings. Specifically, a recent study among university students found increases in psychological need frustration to relate to increases in daytime dysfunction (i.e., higher fatigue and lower vitality) via increases in stress (Campbell, Vansteenkiste, Beyers, & Soenens, 2016). The present results provide further evidence for the explanatory role of stress in the relation between need frustration and fatigue, this time among individuals with UCF.

Interestingly, extending previous findings follow-up analyses revealed that the frustration of each of the three needs (i.e., for autonomy, competence and relatedness) contributed uniquely to higher stress. Seemingly, when individuals feel pressured, incapable of pursuing their daily activities and isolated from important others, they are likely to experience symptoms of stress such as tension and over arousal which in turn erodes energy levels and contributes to fatigue.

Apart from evening fatigue, need frustration and stress also related to more negative sleep cognitions before bedtime. In turn, these negative cognitions were associated with poorer subjective sleep quality as reported in the morning. Consistent with these findings, previous research in insomnia and non-clinical populations also found higher daily stress to relate to lower perceived sleep quality, with cognitive arousal playing an explanatory role (e.g., Morin et al., 2003; Winzeler et al., 2014). In insomnia, stressors during the day have been shown to contribute to increased anxiety at bedtime and subsequent high levels of cognitive pre-sleep arousal. It has been suggested that this pre-sleep arousal triggers selective attention to sleep-related threat cues, resulting in distortions of reality and perceptions of poorer sleep (Harvey, 2002). The present results suggest that similar mechanisms may cause a distorted perception of sleep quality in individuals with UCF.

In addition to sleep quality, higher perceived stress and subsequent negative sleep cognitions also played an intervening role in the relation between need frustration and both subjective and objective quantitative sleep outcomes, with the exception of objective sleep latency. Again, drawing from theories of insomnia, it is hypothesized that cognitive processes such as attention, perception and erroneous beliefs may culminate in real sleep deficit (Harvey, 2002). Seemingly, individuals with UCF may also report shorter sleep duration as a result of cognitive arousal at bedtime and high levels of distress. Hence, it seems likely that cognitive processes play a similar role in UCF. Overall, the present results suggest that in UCF psychological need frustration may spark a negative sequence of events, first by triggering stress and subsequent negative cognitive arousal, which in turn may feed into poorer sleep quality and shorter sleep duration.

Self-reported and Objectively Recorded Sleep

The assessment of both self-reported and objectively recorded sleep outcomes produced some additional findings. First, a moderate correlation was found between the subjective and respective objective registration of all three quantitative sleep parameters (i.e., total sleep time, sleep latency, and wake after sleep onset). These correlations are of moderate effect size, which equally suggests that there is a lack of correspondence between individuals' perception of their sleep and their actual sleep. Future research may want to examine whether the size of this non-correspondence, which reflects a biased perception of one's sleep, varies as a function of psychological characteristics. Furthermore, the mean-level discrepancies between the subjective and objective reports were found to vary as a function of the examined quantitative sleep outcome. Specifically, individuals with UCF overestimated their sleep latency and underestimated their wake after sleep onset. While participants believed that it took them longer to fall asleep than the objective assessment indicated, they underestimated the number of minutes they were awake during the night after sleep onset. The diverging discrepancies for these two indicators helped to explain the lack of a mean-level difference between the subjective and objective *total* sleep time. Similar results, both in terms of the lack of correspondence between subjective and polysomnography measured sleep as well as in terms of mean-level differences were also reported by Creti et al. (2010) in a sample of individuals with CFS.

Perhaps individuals overestimate their sleep latency because they are more alert when trying to fall asleep and are more likely to ruminate about the consequences of not having sufficient sleep. Because individuals are especially likely to recall these negative sleep cognitions in the morning, they may overestimate their sleep latency. In addition, based on their more habitual difficulty to fall asleep (Watson et al., 2003), individuals with UCF may project this experience to the single night that they spent at the sleep lab, thereby neglecting the time it took them to fall asleep that particular night. In contrast, with respect to wake after sleep onset, individuals are likely to be in a more passive mode during their awakenings at night thereby leading them to underestimate the amount of time spent awake. These differential discrepancies between subjectively and objectively recorded sleep outcomes may help to explain why the proposed integrative model including the subjective reports of the sleep parameters generalized to the objectively recorded total sleep time but not to sleep latency or wake after sleep onset. Because participants overestimated the amount of time it took them to fall asleep and underestimated the amount of time they spent awake throughout the night, the predictive power of negative sleep cognitions was reduced. Note though that the differential predictive validity of negative sleep related cognitions in the prediction of objective sleep latency (i.e., .05, *ns*) relative to objective wake after sleep onset (i.e., .10, *ns*) and objective total sleep time (i.e., -.14, p <.05) is a matter of gradation. Additional research is needed to replicate the current pattern of findings before any firm conclusions can be drawn.

Theoretical and Practical Implications

The present findings build on previous research in three important ways. First, by replicating the previously identified association between psychological need experiences and fatigue and sleep outcomes in a heterogeneous group of individuals with UCF. Second, by providing further insight into the explanatory processes that underlie these associations. Specifically, the present findings yielded evidence for the intervening role of both stress and negative sleep cognitions. Third, the present findings show that psychological need experiences not only relate to self-reported sleep parameters, but also relate to an objective indicator of sleep.

In light of these findings therapeutic interventions which seek to help reduce fatigue and sleep disturbances among individuals with UCF could target psychological need experiences. A first important step would be to help individuals to recognize sources of need frustration in their life and regulate their emotional response (i.e., stress and cognitive arousal) to these experiences. One way to do this may to help individuals to develop a more mindful approach (Brown & Ryan, 2003), thereby helping them to learn to adopt an open, non-judgemental awareness of present moment experiences. Indeed, mindfulness has previously been shown to relate to higher need satisfaction (Campbell, Vansteenkiste, Delesie, Mariman et al., 2015; Campbell, Vansteenkiste, Delesie, Soenens et al., 2016) presumably because it aids awareness of and receptivity to cues for need satisfaction. Furthermore, previous studies suggest that being mindful is related to experiencing lower fatigue and higher sleep quality (Campbell, Vansteenkiste, Delesie, Mariman et al., 2015; Howell, Digdon, Buro, & Sheptycki, 2008).

A second step may be to help individuals to achieve more need satisfaction within their own life. For example, individuals' could be helped to identify and participate in daily need satisfying activities (e.g., Weinstein, Khabbaz, & Legate, 2016). A final and important third step would be to foster need satisfaction within the healthcare environment (e.g., Teixeira et al., 2012). This could be achieved by providing individuals with choice and avoiding pressuring strategies (i.e., supporting the need for autonomy), by responding in a warm and empathic manner (i.e., supporting the need for relatedness) and by limiting negative feedback and providing manageable tasks (i.e., supporting the need for competence).

Limitations and future research

The present study has some limitations that can be addressed in future studies. First, although the assessments took place at different points in time, the prospective design precludes the establishment of causal relationships between psychological need frustration and perceived fatigue and the sleep outcomes. For example, fatigue may not only result from stress but may also lead to stress, which in turn may thwart psychological needs. However, the timing of the assessment of the different constructs prevented us from testing such alternative pathways. Hence, future longitudinal or experimental research is needed to examine the direction of effects. Second, fatigue was only measured in the evening and not the following morning. It would be interesting to examine whether (disturbed) sleep outcomes may be involved in the maintenance of daytime symptoms in UCF. Third, although polysomnography is considered the gold standard for objectively measuring sleep, a sleep recording 'snapshot' measured by a single-night in an unnatural, clinical environment lacks ecological validity. Future research could try to overcome this issue by assessing sleep using both polysomnography and wrist actigraphy. While wrist actigraphy may not provide as accurate an estimate of objective sleep, it can be worn at home in a naturalistic environment and may provide a valuable additional source of information. Fourth, in the present study we only assessed relations between the variables of interest and a self-report assessment of sleep quality. We are unaware of the identification of any polysomnography parameter which fully captures the quality of individuals' sleep. Hence, there is a need for future studies to determine how data derived from polysomnography is best used to provide valid qualitative sleep indicators. Finally, our sample was highly heterogeneous and included individuals with a range of different clinical diagnoses. Future research is needed to examine whether these same mechanisms (i.e., stress and negative sleep cognitions) play a similar intervening role in the relation between need experiences and sleep parameters (i.e., both subjective and objective) in non-clinical healthy samples.

Conclusion

In conclusion, individuals with UCF who experience frustration of their basic psychological needs for autonomy, competence and relatedness, are likely to experience more symptoms of stress, which in turn is likely to result in higher evening fatigue. In addition to evening fatigue, need frustration also related to poorer quality and quantity of sleep through (i.e., accounted for by) higher stress and negative sleep cognitions. As poor sleep may contribute to fatigue, these findings indicate the potential need for health care professionals to focus on basic psychological needs as a therapeutic approach in this patient sample, both directly by providing a need supportive healthcare environment (Teixeira et al., 2012), and indirectly, by helping individuals' to identify ways in which they can achieve more need satisfaction within their home environment (Weinstein et al., 2016).

References

Antony, M. M., Bieling, P.J., Cox, B.J., Enns, M. W., & Swinsom, R. P. (1998). Psychometric properties of the 42-item and 21-item versions of the depression anxiety stress scales in clinical groups and a community sample. *Psychological Assessment, 2,* 176-181.

Assefi, N.P., Coy, T.V., Uslan, D., Smith, W.R., & Buchwald, D. (2003). Financial, occupational, and personal consequences of disability in patients with chronic fatigue syndrome and fibromyalgia compared to other fatiguing conditions. *The Journal of Reumatology, 30,* 804-808.

Bartholomew, K. J., Ntoumanis, N., Ryan, R. M., Bosch, J. A., & Thogersen-Ntoumani, C. (2011). Self-Determination theory and diminished functioning: The role of interpersonal control and psychological need thwarting. *Personality and Social Psychology Bulletin*, *37,* 1459-1473. doi: 10.1177/0146167211413125

Campbell, R., Vansteenkiste, M., Delesie, L.M., Soenens, B., Tobback, E., Vogelaers, D., & Mariman, A. (2016). The role of psychological need satisfaction, sleep, and mindfulness in the health related quality of life of people living with HIV. *Journal of Health Psychology.*

Campbell, R., Vansteenkiste, M., Delesie, L.M., Mariman, A.N., Soenens, B., Tobback, E., Van der Kaap-Deeder, J., & Vogelaers, D.P. (2015). Examining the role of psychological need satisfaction in sleep: a self-determination theory perspective. *Personality and Individual Differences, 77,* 199-204.

Campbell, R., Vansteenkiste, M., Soenens, B., & Beyers. (2016). Shifts in University Students' Sleep during an Exam Period: The Role of Basic. Psychological Needs and Stress. *Manuscript submitted for publication.*

Chen, B., Vansteenkiste, M., Beyers, W., Boone, L., Deci, E.L., Duriez, B., Lens, W., Matos, L., Mouratidis, A., Ryan, R.M., Sheldon, K.M., Soenens, B., Van Petegem, S., Van der Kaap-Deeder, J., & Verstuyf, J. (2015). Basic psychological need satisfaction, need frustration, and need strength across four cultures. *Motivation and Emotion, 39,* 216-236.

Crawford, J. R., & Henry, J. D. (2003). The Depression anxiety stress scales (DASS): Normative data and latent structure in a large non-clinical sample. British Journal of Clinical Psychology, 42, 111–131.

Creti, L., Libman, E., Baltzan, M., Rizzo, D., Bailes, S., & Fichten, C.S. (2010). Impaired sleep in chronic fatigue syndrome: how is it best measured? *Journal of Health Psychology, 15(4),* 596-607.

Deci, E.L., & Ryan, R.M. (2000). The “what” and “why” of goal pursuits: Human needs and the self-determination of behavior. *Psychological Enquiry, 11*, 227–268.

Drachler, M.L., Leite, J.C.C., Hooper, L., Hong, C.S., Pheby, D., Nacul, L., Lacerda, E., Campion, P., Killett, A., McArthur, M., & Poland, F. (2009). The expressed needs of people with Chronic Fatigue Syndrome/Myalgic Encephalomyelitis: a systemic review. *BMC Public Health, 9*, 458.

Egan, S.J., Wade, T.D., & Shafran, R. (2011). Perfectionism as a transdiagnostic process: a clinical review. *Clinical Psychology Review, 31(2),* 203-212.

Espie, C, A., Broomfield, N. M., MacMahon, K. M. A., Macphee, L. M., & Taylor, L. M. (2006). The attention-intention-effort pathway in the development of psychophysiologic insomnia: A theoretical review. *Sleep Medicine Reviews, 10,* 210-245.

Fichten, C.S., Libman, E., Creti, L., Amsel, R., Tagalakis, V., & Brender, W. (1998). Thoughts during awake times in older good and poorer sleepers – The self-statement test: 60+. *Cognitive Therapy and Research, 22(1),* 1-20.

Fukuda, K., Straus, S.E., Hickie, I., Sharpe, M.C., Dobbins, J.G., Komaroff, A., Schluederberg, A., Jones, J.F., Lloyd, A.R., Wessely, S., Gantz, N.M., Holmes, J.P., Buchwald, D., Abbey, S., Rest, J., Levy, J.A., Jolson, H., Peterson, D.L.? Vercoulen, J.H.M.M., Tirelli, U., Evengard, B., Natleson, B.H., Steele, L., Reyes, M., & Reeves, W.C. (1994). The chronic fatigue syndrome - a comprehensive approach to its defintions and study. *Annals of Internal Medicine, 121,* 953-959.

Harvey, A.G.A. (2002). Cognitive model of insomnia. *Behaviour Research and Therapy, 2002, 40*, 869-893.

Henry, J.D., and Crawford, J.R. (2005). The short-form of the Depression Anxiety Stress Scales (DASS-21): Construct validity and normative data in a large non-clinical sample. *British Journal of Clinical Psychology,44,* 227-239.

Howell, A. J., Digdon, N. L., Buro, K., & Sheptycki, A. R. (2008). Relations among mindfulness, well-being, and sleep. Personality and Individual Differences, 45, 773–777.

Hu, L., & Bentler, P.M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6*, 1-55.

Iber, C., Ancoli-Israel, S., Chesson, A., & Quan, S.F. (2007). *The AASM manual for scoring of sleep and associated events: rules, terminology and technical specifications.* Westchester, IL: American Academy of Sleep Medicine.

Janssens, K.A.M., Zijlema, W.L., Joustra, M.L., & Rosmalen, J.G.M. (2015). Mood and anxiety disorders in chronic fatigue syndrome, fibromyalgia, and irritable bowel syndrome: results from the lifeLines cohort study. *Psychosomatic Medicine, 77(4)*, 449-457.

Kline, R. B. (2005). *Principles and practice of structural equation modeling*. New York: Guilford Press.

Little, R.J.A., & Rubin, D.B. (1987). *Statistical analysis with missing data*. New York: Wiley.

Lopez, C., Antoni, M., Penedo, F., Weiss, D., Cruess, S., Segotas, M.C., Helder, L., Siegel, S., Klimas, N., & Fletcher, M.A. (2011). A pilot study of cognitive behavioral stress management effects on stress, quality of life, and symptoms in persons with chronic fatigue syndrome. *Journal of Psychosomatic Research, 70,* 328-334.

Lovibond, S.H., & Lovibond, P.F. (2004). *Manual for the Depression Anxiety Stress Scales, second edition.* Psychology Foundation, Sydney.

Lyvers, M., Makin, C., Toms, E., Thorberg, F. A., Samios, C. (2014). Trait mindfulness in relation to emotional self-regulation and executive function. *Mindfulness, 5*, 619-625.

MacKinnon, D. P., Lockwood, C. M., & Williams, J. (2004). Confidence limits for the indirect effect: Distribution of the product and resampling methods. *Multivariate Behavioral Research*, *39*, 99–128.

Mariman, A., Delesie, L., Tobback, E., Hanoulle, I., Sermijn, E., Vermeir, P., Pevernagie, D., & Vogelaers, D. (2013a). Undiagnosed and comorbid disorders in patients with presumed chronic fatigue syndrome. *Journal of Psychosomatic Research*, *75,* 491-496.

Mariman, A.N., Vogelaers, D.P., Tobback, E., Delesie, L.M., Hanoulle, I.P., & Pevernagie, D.A. (2013b). Sleep in the chronic fatigue syndrome. *Sleep Medicine Reviews, 17(3),* 193-199.

Monk, T.H., Reynolds, C.F., Kupfer, D.J., Buysse, D.J., Coble, P.A., Hayes, A.J., Machen, M.A., Petrie, S.R., & Ritenour, A.M. (1994). The Pittsburgh sleep diary. *Journal of Sleep Research, 3,* 111-120.

Morin, C.M., Rodrigue, S., & Ivers, H. (2003). Role of stress, arousal, and coping skills in primary insomnia. *Psychosomatic Medicine, 65*, 259–267.

Oyeflaten, I., Midtgarden, I.J., Maeland, S., Eriksen, H.R., & Magnussen, L.H. (2014). Functoning, coping and work status three years after participating in an interdisciplany, occupational rehabilitation program. *Scandinavian Journal of Public Health, 42(5),* 425-433.

Prins, J.B., Bos, E., Huibers, M.J.H., Servaes, P., Werf, S.P., & van der Meer, J.W.M. (2004). Social support and the persistence of complaints in chronic fatigue syndrome. *Psychotherapy and Psychosomatics, 73,*174-182.

Russell, C., Wearden, A.J., Fairclough, G., Emsley, R.A., & Kyle, S.D. (2016). Subjective but not actigraphy-defined sleep predicts next-day fatigue in chronic fatigue syndrome: a prospective daily diary study. *Sleep, 39(4),* 937-944.

Ryan, R. M., & Deci, E. L. (2008). From ego depletion to vitality: Theory and findings concerning the facilitation of energy available to the self. *Social and Personality Psychology Compass*, 2/2, 702-717.

Savard, A., Joussemet, M., Pelletier, J. E., & Mageau, G. (2013). The benefits of autonomy support for adolescents with severe emotional and behavioral problems. Motivation and Emotion, *37*, 688-700.

Shahid, A., Shen, J., & Shapiro, C.M. (2010). Measurements of sleepiness and fatigue. *Journal of Psychosomatic Research, 69,* 81-89.

Teixeira, P.J., Carraca, E.V., Markland, D., Silva, M.N., & Ryan, R.M. (2012). Exercise, physical activity, and self-determination theory: a systematic review. *International Journal of Behavioral Nutrition and Physical Activity, 9,* 78.

Valerio, T.D., Kim, M.J., & Sexton-Radek, K. (2016). Association of stress, general health, and alcohol use with poor sleep quality among U.S. college students. *American Journal of Health Education, 47(1),* 17-23.

Van der Kaap-Deeder, J., Vansteenkiste, M., Soenens, B., & Mabbe, E. (2016). Children's daily well-being: The role of mothers', teachers', and siblings' autonomy support and psychological control. *Developmental Psychology*.

Van der Kaap-Deeder, J., Vansteenkiste, M., Van Petegem, S., Raes, F., & Soenens, S. (2016). On the integration of need-related autobiographical memories among late adolescents and late adults: The role of depressive symptoms and self-congruence. *European Journal of Personality.*

Vansteenkiste, M., & Ryan, R.M. (2013). On psychological growth and vulnerability: basic psychological need satisfaction and need frustration as a unifying principle. *Journal of Psychotherapy Integration, 23,* 263-280.

Verstuyf, J., Vansteenkiste, M., Soenens, B., Boone, L., & Mouratidis, A. (2013). Daily ups and downs in women's binge eating symptoms: The role of basic psychological needs, general self-control, and emotional eating. Journal of Social & Clinical Psychology, 32, 335–361.

Watson, D., O'Hara, M.W., Simms, L.J., Kotov, R., Chmielewski, M., mcDade-Montez, E.A., Gamez, W., & Stuart, S. (2007). Development and validation of the Inventory of Depression and Anxiety Symptoms (IDAS). *Psychological Assessment, 19(3),* 253-268.

Watson, N.F., Kapur, V., Arguelles, L.M., Goldberg, J., Schmidt, D.F., Armitage, R., & Buchwald, D. (2003). Comparison of subjective and objective measures of insomnia in monozygotic twins discordant for chronic fatigue syndrome. *Sleep, 26(3),* 324-328.

Weinstein, N., & Ryan, R. M. (2011). A self-determination theory approach to understanding stress incursion and responses. *Stress and Health, 27,* 4-17.

Weinstein, N., Khabbaz, F., & Legate, N. (2016). Enhancing need satisfaction to reduce psychological distress in Syrian refugees. *Journal of Consulting and Clinical Psychology* PMID 27018533.

Willemsen, J., Markey, S., Declercq, F., & Vanheule, S. (2011). Negative emotionality in a large community sample of adolescents: The factor structure and measurement invariance of the short version of the depression anxiety stress scales (DASS-21). *Stress and health, 27,* 120-128.

Winzeler, K., Voellmin, A., Schäfer, V., Meyer, A.H., Cajochen, C., Wilhelm, F.H., & Bader, K. (2014). Daily stress, presleep arousal, and sleep in healthy young women: a daily life computerized sleep diary and actigraphy study. *Sleep Medicine, 15,* 359-366.

Wood, A.M., Joseph, S., Lloyd, J., & Atkins, S. (2009). Gratitude influences sleep through mechanism of pre-sleep cognitions. *Journal of Psychosomatic Research, 66(1),* 43-48.

Day-to-day Fluctuations in Subjective Energy and Sleep in Chronic Fatigue Syndrome:

The Role of Psychological Need Experiences[1]

Previous findings indicate that patients' with Chronic Fatigue Syndrome (CFS) report significant day-to-day fluctuations in subjective energy and sleep. Herein, we examined whether daily variation in the satisfaction and frustration of the basic psychological needs for autonomy, competence, and relatedness, would contribute to daily variation in subjective energy and quality and quantity of sleep as well as whether daily variation in sleep would contribute to daily need experiences. Ninety CFS patients (92% female; *M*age = 42.10) completed a diary for 14 days which assessed need-based experiences and subjective energy every evening and sleep every morning. Result indicated that subjective energy, sleep, and need experiences fluctuated significantly from day-to-day. Daily need satisfaction related to less daily fatigue and more daily vitality, while the opposite pattern was observed for daily need frustration. Daily need frustration was also uniquely related to poorer daily sleep quality. Lastly, daily sleep quality was uniquely related to more daily need satisfaction and less daily need frustration. The present findings underscore the role of need experiences in contributing to daily subjective energy and sleep quality in CFS and suggest that poor sleep quality may create vulnerability for experiences of need frustration.

1 Campbell, R., Vansteenkiste, M., Delesie, L., Tobback, E., Mariman A., & Vogelaers, D. (under revision). Day-to-day fluctuations in subjective energy and sleep in chronic fatigue syndrome: The role of psychological need experiences. *Manuscript under revision for Health Psychology*.

Introduction

Chronic fatigue syndrome (CFS) is characterized by medically unexplained fatigue that persists for 6 months or more that is insufficiently alleviated by rest (Fukuda et al., 1994). Nonrestorative sleep is a key symptom of CFS (Fukuda et al., 1994) and up to 95% of CFS patients report unrefreshing sleep (Nisenbaum, Jones, Unger, Reyes, & Reeves, 2003). Previous findings suggest that sleep disturbances play a role in exacerbating and maintaining symptoms of CFS (e.g., Gotts, Newton, Ellis, & Deary, 2015; Milrad et al., 2017; Russell, Wearden, Fairclough, Emsley, & Kyle, 2016). Importantly, rather than being stable over time, a few diary studies have demonstrated that both fatigue and quality and quantity of sleep vary considerably within CFS patients from day-to-day (Kempke, Luyten, Claes, Goosens et al., 2012; Kempke, Luyten, Claes, Wambeke et al., 2013; Russell et al., 2016). Yet, very few studies have examined factors that account for such rises and falls in fatigue and sleep in the daily flow of life within this patient group.

One theoretical framework which may be helpful for examining day-to-day predictors of fatigue and sleep among CFS patients is Self-Determination Theory (SDT; Deci & Ryan, 2000; Vansteenkiste & Ryan, 2013). SDT conceives of three basic psychological needs which have consistently been shown to relate to individuals' subjective vitality which, in contrast to fatigue, is a positive indicator of energy described as the subjective experience of possessing energy and aliveness (Ryan & Frederick, 1997). In addition to energy levels, recent findings also suggest that SDT's basic psychological needs are implicated in people's sleep (Campbell, Vansteenkiste, Delesie, Mariman et al., 2015; Campbell, Vansteenkiste, Delesie, Soenens et al., 2016). Hence, drawing from SDT, in the present study we sought to examine the day-to-day (i.e., within-person) association between the satisfaction and frustration of the basic psychological needs for autonomy, competence, and relatedness and indicators of subjective energy (i.e., fatigue and vitality) and quality and quantity of sleep among CFS patients.

Day-to-day Variation in Subjective Energy and Sleep in CFS

The few previous diary studies that examined day-to-day variation in subjective energy among CFS patients focused exclusively on negative indicators of energy (i.e., fatigue) (i.e., Kempke, Luyten, Claes, Goosens et al., 2012; Kempke, Luyten, Claes, Wambeke et al., 2013). Previous findings demonstrated that the majority (i.e., approximately 70%) of the variability in fatigue was situated within individuals (rather than between-individuals), indicating that CFS patients report substantial fluctuations in fatigue from day-to-day (e.g., Kempke et al., 2013). However, previous diary studies neglected to examine whether CFS patients report similar fluctuations in positive indicators of energy, such as vitality, from day-to-day. Indeed, rather than being perfectly opposite from one another, fatigue and vitality are likely to be distinct constructs. That is, if on a given day a CFS patient reports less fatigue that does not necessarily mean that they feel vital. Conversely, if an individual with CFS reports that they do not feel particularly vital, that does not necessarily imply that they feel fatigued. In light of this distinction, it is important that research among CFS patients seeks not only to examine factors that contribute to day-to-day variability in fatigue, but also seeks to identify factors that may contribute to enhanced vitality.

Another recent diary study demonstrated that CFS patients' also report significant variability in subjective quality and quantity of sleep from day-to-day (Russell et al., 2016). Together, these previous findings suggest that it is important for research to examine why it is that on some days CFS patients' report less subjective energy and/or poorer sleep, while on others days patients' may report more subjective energy and/or better sleep. With regard to subjective energy, previous diary studies have focused exclusively on the role of more stable between-patient differences in for example, self-critical perfectionism (Kempke, Luyten, Claes, Goosens et al., 2012) and experiences of childhood trauma (Kempke, Luyten, Claes, Wambeke et al., 2013) in the prediction of levels of fatigue across days. However, to identify predictors of daily variation in subjective energy and sleep, it is important to examine factors that fluctuate dynamically from day-to-day. For example, in their examination of predictors of daily sleep Russell et al. (2016) investigated whether dynamic processes within the day (i.e., cognitive and somatic arousal) related to daily variability in CFS patients' self-reported sleep. The present study aimed to take a new step in the identification of daily predictors by examining the role of daily need-based experiences as conceived within SDT.

Self-Determination Theory: Basic Psychological Needs

SDT posits three basic psychological needs which it claims are inherent and universally critical for optimal functioning and human thriving. The need for *autonomy*, involves experiencing a sense of volition and self-endorsement in one's activities, the need for *competence* refers to feeling capable and effective in achieving desired outcomes and the need for *relatedness* refers to experiencing a sense of reciprocal care and closeness with important others (Deci & Ryan, 2000). Within SDT, the satisfaction of these three basic psychological needs is said to energize behavior and contribute to both psychological and physical well-being. Conversely, the frustration of these same needs is said to deplete energy and bring about maladaptive outcomes (Ryan & Deci, 2008; Vansteenkiste & Ryan, 2013).

Unlike a lack of need fulfillment which would lead to less energy and lower well-being, need frustration is said to occur when needs are actively blocked or thwarted thereby depleting resources and eliciting ill-being. To provide an example, an individual may experience little mastery when carrying out a particular task (i.e., low competence satisfaction), but this may not necessarily result in them feeling like a complete failure (i.e., high competence frustration). In other words, similar to the distinction between fatigue and vitality, a lack of need satisfaction does not automatically imply the presence of need frustration, and conversely an absence of need frustration is not sufficient for need satisfaction to occur. When psychological needs are frustrated individuals' experience pressure to think, feel or act a certain way (autonomy frustration), feelings of failure and inadequacy (competence frustration) and exclusion and alienation (relatedness frustration; Vansteenkiste & Ryan, 2013). This distinction between need satisfaction and need frustration is important because previous studies have shown need satisfaction to play a critical role in the prediction of adaptive functioning whereas need frustration has been shown to be primarily related to maladaptive functioning (e.g., Bartholomew et al., 2011; Van der Kaap-Deeder et al., 2016).

In accordance with SDT's claims that need satisfaction energizes behavior, a number of studies have demonstrated that when individuals' feel satisfied in their needs for autonomy, competence, and relatedness their vitality is enhanced (for an overview see Ryan & Deci, 2008). For example, one study employing a between-person design found psychological need satisfaction to relate positively to vitality across four distinct cultures, irrespective of whether individuals valued or desired the satisfaction of these needs (Chen et al., 2015). Conversely, in a cross-sectional study of employees, low psychological need satisfaction related to higher exhaustion (Van den Broeck, Vansteenkiste, De Witte, & Lens, 2008). Several diary studies have also demonstrated associations between need satisfaction and indicators of subjective energy from day-to-day. For example, diary studies have shown that on days that individuals experience more satisfaction of their psychological needs they report more vitality. These within-person associations emerged among university students (Reis, Sheldon, Gable, Roscoe & Ryan, 2000) and older adults (Ryan, Bernstein, & Brown, 2010). Similarly, another diary study among working adults found that need satisfaction in the free evening hours after work contributed to a better work recovery status (i.e., lower anxiety and higher vigour) at the end of a working day (Van Hooff & Geurts, 2014). However, despite evidence suggesting that need satisfaction is likely to boost energy, research is yet to examine whether these day-to-day associations extend to clinical populations in which energy is severely compromised, such as individuals with CFS. Furthermore, to the best of our knowledge no studies have yet examined the differential role of need satisfaction and need frustration in the prediction of both positive and negative indicators of subjective energy (i.e., vitality and fatigue).

Previous research provides some indirect evidence for an association between psychological need experiences and subjective energy among CFS patients. For example, patients who believe that they have no control over their illness report lower vitality (Heijmans, 1998), whereas a higher sense of control over symptoms predicts improvements in fatigue (Schreurs, Veehof, Passade, & Vollenbroek-Hutten, 2011). Patients who experience no control over their symptoms are likely low in competence and autonomy as they presumably feel less capable of managing their illness and less able to participate in the activities that they truly value. In addition, CFS patients' relationship dissatisfaction has been found to be negatively associated with improvements in fatigue following treatment (Verspaandonk, Coenders, Bleijenberg, Lobbestael & Knoop, 2015). Furthermore, a considerable number of studies have found self-critical perfectionism, which involves a mixture of high personal standards and harsh self-scrutiny, to be implicated in CFS. For example, a diary study demonstrated that CFS patients higher in self-critical perfectionism reported higher levels of fatigue across a 14 day period (Kempke, Luyten, Claes, Wambeke et al., 2013). This is relevant to the present research because self-critical perfectionism has previously been shown to engender psychological need frustration (Boone et al, 2014). Although these studies did not directly assess the relation between SDT's basic needs and indicators of energy, together they provide some evidence that need-based experiences may contribute to fatigue and vitality in CFS patients. Furthermore, previous findings among non-clinical populations (e.g., Chen et al., 2015; Van der Kaap-Deeder et al., 2016) and recent theorizing (Vansteenkiste & Ryan, 2013) suggest that need satisfaction may be especially related to vitality whereas need frustration may be especially related to fatigue.

Apart from subjective energy, basic psychological needs have also been found to play a role in individuals' sleep. Two studies examining between-person differences revealed that higher need satisfaction related to higher quality of sleep and somewhat longer sleep duration within a non-clinical population (Campbell, Vansteenkiste, Delesie, Mariman et al., 2015) and to higher quality of sleep among HIV patients (Campbell, Vansteenkiste, Delesie, Soenens, et al., 2016). Presumably, individuals who experience frustration of their psychological needs encounter more negative daily experiences which engender stress and cognitive arousal before bedtime, which in turn interfere with sleep at night. In line with this, a recent cross-sectional prospective study (Campbell, Tobback, et al., 2016) among individuals with unexplained chronic fatigue (i.e., who had not yet received a diagnosis of CFS) indicated that participants who experienced higher need frustration during the past week also reported more stress and negative sleep-related cognitions, which in turn related to poorer quality and quantity of sleep during a stay at a sleep laboratory (Campbell, Tobback et al., 2016). To the best of our knowledge, only one study to date has examined daily predictors of sleep among CFS patients. In this study cognitive and somatic arousal before sleep were found to predict poorer self-reported sleep the following morning (Russell, et al., 2016). This finding, in combination with previous research linking need frustration to negative sleep-related cognitions and stress, which presumably involves somatic arousal, provides indirect evidence for the hypothesized day-to-day association between need-based experiences and sleep among CFS patients.

In addition to psychological need experiences predicting sleep at night, the reverse may also be possible, namely that quality and quantity of sleep may contribute to next-day need experiences. Previous research indicates that sleep disturbances exacerbate symptoms of CFS (Gotts, et al., 2015; Milrad et al., 2017; Russell et al., 2016) and suggest that CFS patients are likely to be more debilitated by their condition following a night of poor sleep. For example, in a recent qualitative study CFS patients' described the detrimental impact of poor sleep on their ability to carry out simple daily tasks and also stated that their sleep disturbances interfered with their capacity to socialize with friends and family (Gotts et al., 2015). These findings indicate that following a night of poor sleep individuals with CFS are likely to feel less capable of participating in the activities that they value, including socializing, thereby precluding psychological need fulfillment. In sum, there is some evidence to suggest that daily psychological need experiences may not only predict but may also follow from poor sleep.

Present Study

The global objective of the present diary study among CFS patients was to examine whether day-to-day (i.e., within-person) variation in need-based experiences would relate to variation in (a) fatigue and vitality as reported in the evening, and in (b) quality and quantity of sleep as reported the following morning. Although fatigue is of course a central outcome among CFS patients we deemed it important to include a positive indicator of energy as an outcome (i.e., vitality) so as to focus not only on factors which account for energy depletion but also on factors which contribute to enhanced energy. The following four hypotheses were examined.

First, given the paucity of previous diary studies among CFS patients, our first aim was to examine whether there would be any day-to-day variation in fatigue, vitality, sleep and need-based experiences in this population, which is a prerequisite for examining their interrelation from day-to-day. Based on a few previous diary studies (e.g., Kempke et al., 2012; Kempke, et al., 2013), we expected the proportion of the overall variation to be substantial from day-to-day. Our second aim was to investigate whether evening reports of fatigue and vitality would be predicted by evening reports of need-based experiences, thereby examining within-day associations. With respect to evening fatigue and vitality, we expected CFS patients' who experienced more need frustration throughout the day to have less subjective energy, manifested through higher fatigue and less vitality. While need frustration may erode energy, need satisfying experiences may be conducive to energy levels from day-to-day (Hypothesis 2). However, the effects of daily need-based experiences may not only contribute to CFS patients' subjective energy, but may also play a role in their sleep. Hence, our third aim was to examine whether morning reports of quality and quantity of sleep would be predicted by need-based experiences reported the previous evening, thereby examining across-day associations. We expected that the more patients reported need frustrating experiences from day-to-day, the more they would be prone to poorer quality and possibly also reduced quantity of sleep because these experiences would likely engender more cognitive and somatic arousal at bedtime which would obstruct restful sleep at night. The opposite pattern was expected for need satisfying experiences, which may be conducive to better sleep (Hypothesis 3).

Lastly, need-based experiences may not only be conducive to, but may also stem from sleep at night. Our fourth aim was therefore to examine the within-day association between morning reports of quality and quantity of sleep and evening reports of need-based experiences. Given the assumed restorative and energizing function of sleep, we hypothesized that individuals who reported higher daily quality and quantity of sleep would have more energy which would facilitate their awareness of, opportunities for, and effective engagement in need-satisfying activities and would therefore contribute to higher daily need satisfaction and lower daily need frustration (Hypothesis 4).

Method

Participants and Procedure

Participants were recruited from a multidisciplinary tertiary care reference centre for chronic fatigue at the Ghent University Hospital between May 2013 and December 2014. Participants had undergone medical and psychiatric examination to rule out any physiological or psychopathological explanation for symptoms of chronic fatigue. Participants were eligible for inclusion if they had received a diagnosis of CFS according to the Fukuda criteria (Fukuda et al., 1994). Additional inclusion criteria were Dutch-speaking, age 18 or older as well as no children under the age of 3 and no night shift work, given their likely impact on sleep. Eligible participants were informed about the study during a consultation with their physician. A research assistant then explained the study requirements and emphasized its voluntary and confidential nature. Written informed consent was obtained from all participants and the study was approved by the host University Hospital's Ethical Review Board.

Participants completed a questionnaire which assessed demographic information and individual characteristics (e.g., general need experiences and quality and quantity of sleep) prior to beginning the diary study and received a diary which they were required to fill in twice a day for 14 days; once in the evening before going to bed, and once in the morning after waking up. Participants were sent reminders to stimulate diary completion and were given a stamped addressed envelope, which they used to return the study materials.

One hundred and eighty-eight patients signed an informed consent and agreed to participate. Of the 188 who agreed to participate, 120 returned a questionnaire and diary to the researchers, resulting in a response rate of 63.83%. Of the 120, 25% had incomplete data and were excluded from further analyses. Hence, the final sample consisted of 90 patients. Consistent with other studies among CFS patients (e.g., Kempke, Luyten, Claes, Wambeke et al., 2013; Russell et al., 2016), the majority of participants were female (92 %) and the mean age was 42.10 (SD = 10.46; range = 18-59).

Measures

Person-level measures

Need satisfaction and need frustration. To control for between-person differences in need satisfaction and need frustration in the primary analyses, general need experiences were assessed using the Basic Psychological Need Satisfaction and Need Frustration Scale (BPNSNFS; Chen et al., 2015). The scale consists of 24 items, 8 items per need, 4 of which tap into need satisfaction and 4 of which tap into need frustration. All participants rated on a scale of 1 (*not at all true*) to 5 (*very true*) as to whether they felt their needs for autonomy (e.g., "During the past month I felt that my decisions reflected what I really wanted" or "I felt forced to do many things that I didn't choose to do"), competence (e.g., "During the past month I felt capable of achieving my goals" or "I had serious doubts about whether I could do things well") and relatedness (e.g., "During the past month I felt connected with the people who care about me and who I care about" or "I felt excluded from the group that I want to belong to") were satisfied or frustrated during the past month. Two composite scores were created by averaging the 12 items assessing need satisfaction (α = .86) and the 12 items that assessed need frustration (α = .85) which were used as control variables in the primary analyses.

Pittsburgh Sleep Quality Index. To control for between-person differences in quality and quantity of sleep in the primary analyses, general quality and quantity of sleep was assessed using the Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989). The PSQI consists of 19 items which generate scores on 7 components: subjective poor sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of hypnotics, and daytime dysfunction. For descriptive purposes a global PSQI score was calculated by summing the 7 component scores. A global PSQI score of > 5 distinguishes between good and poor sleepers, with higher scores indicating worse sleep quality. The sleep quality and sleep quantity component scores were used as control variables in the primary analyses.

Day-Level Measures: Evening

Need satisfaction and need frustration. The BPNSNFS was slightly adapted to assess the daily satisfaction and frustration of the psychological needs for autonomy, competence, and relatedness (e.g., "Today I felt that my decisions reflect what I really wanted" or "Today I felt pressured to do many things that I didn't choose to do"). In line with previous diary studies (e.g., Van der Kaap-Deeder et al., 2016) two composite scores were created by averaging the 12 items assessing daily need satisfaction and the 12 items assessing daily need frustration. The composite scores for daily need satisfaction (average α = .88; range across days = .82 - .91) and daily need frustration (average α = .88; range across days = .82 - .90) had good reliability.

Fatigue. Daily fatigue was assessed using the lassitude subscale from the Inventory of Depression and Anxiety Symptoms (IDAS; Watson et al., 2007). The 6-item scale was adapted to assess symptoms of fatigue experienced during the past day (e.g., "Today I felt sleepy and drowsy"). All items were rated on a 5-point scale ranging from 1 (*not at all*) to 5 (*very much so*). The scale had an average reliability of .84; range across days = .79 - .90.

Vitality. Daily vitality was assessed using the General Vitality Scale (Ryan & Frederick, 1997). The scale consists of 7 items and was adapted to assess subjective vitality during the past day (e.g., "*Today I felt very energetic*"). All items were rated on a 5-point Likert scale ranging from 1 (*do not agree at all*) to 5 (*completely agree*). The scale had good reliability (average α = .82; range across days = .75 - .87).

Day-Level Measures: Morning

Sleep quality. Daily sleep quality was assessed using one visual analogue scale (VAS) from the Pittsburgh Sleep Diary (Monk et al., 1994) which assessed the previous night's sleep quality (i.e., "How was your sleep quality last night"?) and one self-developed VAS which assessed the degree to which the previous night's sleep was experienced as restorative (i.e., "How restorative was your sleep"). Participants rated each VAS on a scale of 0 (*extremely poor* or *not at all restorative*) to 100 (*extremely good* or *completely restorative*). A composite score for sleep quality was created by averaging the scores on each VAS. The composite score had an average reliability of .73; range across days=.66-.84.

Sleep quantity. Daily sleep quantity was measured using four open-ended questions from the Pittsburgh Sleep Diary (Monk et al., 1994) which assessed evening bed-time, morning wake-time, number of minutes taken to fall asleep (sleep latency) and number of minutes spent awake during the night after initial sleep onset (wake after sleep onset). Total time in bed was calculated using the bed and wake times. Daily sleep duration was then calculated by subtracting sleep latency and wake after sleep onset from the total time in bed.

Plan of analysis

The present data consisted of repeated measurements on 14 consecutive days (i.e., Level 1) nested within 90 individuals (i.e., Level 2), and were thus hierarchically structured. To take both the between- and within-person differences into account, multilevel analyses were performed using MLwiN version 2.32. All predictor variables at Level 1 were group-mean centered (i.e., centered around the person's mean) and all predictor variables at Level 2 were centered around the grand mean, with the exception of gender which was uncentered (0 = males; 1 = females). Background characteristics (i.e., age and gender) were included as Level 2 predictors in all models. There were 3% missing values which were treated as structural missing values by MLwiN software.

We began by examining whether there was significant day-to-day variability in the outcomes (i.e., fatigue, vitality, sleep quality, sleep quantity, need satisfaction- & frustration) by estimating intercept-only models with no predictor variables (Hypothesis 1). These models partitioned the total variation in each outcome into variation at the between- and within- person level and constituted base-line models against which subsequent models were compared.

Next, we examined whether daily variation in need satisfaction and need frustration would relate to daily subjective energy by testing two separate models (i.e., one for each outcome) and entering composite scores of daily need satisfaction and need frustration simultaneously (i.e., at Level 1) as predictors of daily fatigue and vitality (i.e., Hypothesis 2). Then, we examined whether daily variation in evening reports of need satisfaction and need frustration would relate to quality and quantity of sleep as reported the following morning. This was done by testing two more models (i.e., one for each outcome) and entering daily need satisfaction and need frustration as predictors of morning reports of daily quality and quantity of sleep (Hypothesis 3). Between-person differences in general need satisfaction and need frustration were controlled for in these four models (i.e., at Level 2).

Lastly, we investigated whether daily variation in quality and quantity of sleep would relate to daily experiences of need satisfaction and need frustration (Hypothesis 4). This was examined by testing two models (i.e., one for each outcome) in which we entered daily sleep quality and sleep quantity (i.e., level 1) as reported in the morning as predictors of daily need satisfaction and need frustration as reported in the evening. In these final models between-person differences in quality and quantity of sleep were controlled for (i.e., at Level 2).

Results

Preliminary analyses

Descriptive statistics and correlations. Means, standard deviations and correlations between all study variables are shown in Table 1. For descriptive purposes, the daily measures were aggregated across the 14 day period. With regard to the day-level measures, need satisfaction was negatively related to fatigue and positively related to vitality, whereas need frustration related to both variables in the opposite direction. With respect to the daily sleep outcomes, need satisfaction was only positively related to sleep quality, whereas need frustration was unrelated to both sleep parameters. Finally, of note, rather than being perfectly negatively correlated, the correlation between daily fatigue and daily vitality was -.56 suggesting that rather than being perfectly opposite, they are indeed distinct constructs. The mean global PSQI score in this sample was 9.71; SD = 3.77, with 87.2% of the patients scoring above the cut off of 5.

Background variables. To examine the relation between background characteristics and the study variables a MANCOVA was performed with gender as a fixed factor, age as a covariate and all study variables as dependent variables. Neither age (F[10,76] = 1.08, *ns*) nor gender (F[10,76] = .59, *ns*) yielded a significant multivariate effect.

Table 1

Means, Standard deviations, Intraclass correlations, and Correlations between Person-level and Daily-level Variables.

	1	2	3	4	5	6	7	8	9	10
Day-level measures										
Evening measures										
1. Need satisfaction	-									
2. Need frustration	-.77**	-								
3. Fatigue	-.24*	.26**	-							
4. Vitality	.43**	-.30**	-.56**	-						
Morning measures										
5. Sleep quality	.22*	-.17	-.45**	.58**	-					
6. Sleep quantity	.08	-.09	.12	-.08	.08	-				
Person-level measures										
7. Need satisfaction	.55**	-.45**	.07	.34**	.08	-.02	-			
8. Need frustration	-.52**	.59**	.19	-.20**	.04	-.04	-.67**	-		
9. PSQI Sleep quality	-.13	.06	.08	-.03	-.40**	-.27**	-.03	.02	-	
10. PSQI Sleep quantity	-.06	.01	.01	.08	-.28**	-.35**	.11	-.10	.55**	-
Mean	3.57	2.08	2.90	2.26	41.51	470.85	3.46	2.61	1.62	.70
SD	.50	.56	.63	.46	15.01	77.86	.65	.70	.78	.88
ICC	.58	.58	.38	.38	.20	.28	-	-	-	-

Note. ICC = intraclass correlation coefficient

**p*<.05, ***p*<.01.

Primary analyses

Hypothesis 1: Daily variability in fatigue, vitality, sleep and need-based experiences. First, intercept-only models were estimated which allowed us to calculate intra-class correlations (ICC'S; see Table 1). An approximate estimation of the amount of variation in each variable from day-to-day can be calculated by subtracting the ICC's from 1. For example, ICC'S indicated that approximately 62% (i.e., 1 - .38) of the variance in both fatigue and vitality was situated at the daily level. This indicated that rather than remaining stable over the 14 day period, patient reports of fatigue and vitality varied significantly from day-to-day. As shown in Table 1, all ICC values indicated significant variation in all study variables from day-to-day, with poor sleep quality displaying the most daily variation (i.e., approx. 80%) and need-based experiences displaying the least daily variation (i.e., approx. 42%). Overall, these findings confirmed that a multilevel analytical approach was warranted.

Hypothesis 2: Within-day associations between daily psychological need experiences and daily fatigue and vitality. Next, we examined whether daily variation in need satisfaction and need frustration would relate to day-to-day variability in fatigue and vitality. As demonstrated in Table 2, daily need satisfaction was negatively related to daily fatigue (b = -.25, $p < .001$) and positively related to daily vitality (b = .38, $p < .001$). In contrast, daily need frustration was positively related to daily fatigue (b = .26, $p < .001$) and negatively related to daily vitality (b = -.18, $p < .001$). Of note, the positive relation between daily need satisfaction and daily vitality (i.e., b = .38, $p < .001$) was more pronounced than the negative relation between daily need frustration and daily vitality (i.e., b = -.18, $p < .001$).

Hypothesis 3: Examining across-day associations between daily psychological need experiences and daily quality and quantity of sleep. Next, we examined whether daily variation in need satisfaction and need frustration would relate to daily quality and quantity of sleep as reported in the morning. As shown in Table 2, daily need frustration was negatively related to daily sleep quality (b = -3.61, $p < .001$) and unrelated to daily sleep quantity (b = -1.38, *ns*), whereas

Table 2

Daily Subjective Energy and Quality & Quantity of Sleep as a Function of Daily Need Satisfaction & Need Frustration.

	Fatigue		**Vitality**		**Sleep quality**		**Sleep quantity**	
	Null model *B (SE)*	Model 1 *B (SE)*	Null model *B (SE)*	Model 2 *B (SE)*	Null model *B (SE)*	Model 3 *B (SE)*	Null model *B (SE)*	Model 4 *B (SE)*
Fixed effects								
Overall Intercept	3.03 (.06)***	3.10 (.24)***	2.26 (.04)***	2.38(.18)***	41.87(1.42)***	39.35 (6.11)***	471.38 (6.98)***	478.25 (28.28)***
Day level measures								
Need satisfaction		-.25 (.06)***		.38(.05)***		.81 (1.57)		1.99 (8.88)
Need frustration		.26 (.06)***		-.18(.04)***		-3.61 (1.36)**		-1.38(7.77)
Person level measures								
Need satisfaction		-.06 (.11)		.25(.08)**		2.77(2.76)		-15.06(12.77)
Need frustration		.06 (.10)		.06(.08)		1.99 (2.61)		-15.50(12.10)
Random effects								
u_0	.34 (.05)***	.35 (.06)***	.20(.03)***	.21(.03)***	217.20 (31.09)***	232.18 (37.86)***	5140.63 (750.85)***	4737.19 (811.81)***
u_1		-		-		-		-
u_2		-		-		-		-
-2*loglikelihood	3997.41	2895.32	3200.47	2174.44	13469.11	10083.57	18430.74	13909.24

*Note.**p<.05, **p<.01, ***p<.001.

Coefficients shown are unstandardized coefficients.

daily need satisfaction was unrelated to both daily quality (b = .81, *ns*) and quantity of sleep (b = 1.99, *ns*).

Hypothesis 4: Examining within-day associations between daily quality and quantity of sleep and daily psychological need experiences. Lastly, we examined whether day-to-day variation in quality and quantity of sleep as reported in the morning, would relate to daily need satisfaction and daily need frustration as reported in the evening. As shown in Table 3, daily sleep quality was positively related to daily need satisfaction (b = .004, $p < .001$) and negatively related to daily need frustration (b = -.01, $p < .001$). Daily sleep quantity, on the other hand, was unrelated to daily experiences of need satisfaction- (b = -.000, *ns*) and frustration (b = .000, *ns*).

Table 3

Daily Need Satisfaction & Need Frustration as a Function of Daily Quality & Quantity of Sleep.

	Need Satisfaction		**Need Frustration**	
	Null Model	Model 1	Null Model	Model 2
Fixed effects				
Overall Intercept	3.62 (.05)***	3.59 (.21)***	2.11(.05)***	1.96 (.22)***
Day level measures				
Sleep quality		.004 (.001)***		-.01 (.001)***
Sleep quantity		-.000 (.000)		.000 (.000)
Person level measures				
PSQI sleep quality		-.10 (.09)		.10 (.09)
PSQI sleep duration		-.001 (.08)		-.05 (.08)
Random effects				
u_0	26 (.04)***	.27 (.04)***	.33(.04)***	.28 (.05)***
u_1				
u_2				
-2*loglikelihood	2326.74	1614.45	2693.68	1830.90

Note. *p<.05, **p < .01, p***<.001
Coefficients shown are unstandardized coefficients.

Discussion

Although a few previous studies (e.g., Kempke et al., 2012; Kempke et al., 2013; Russell et al., 2016) demonstrated that CFS patients' report significant fluctuations in subjective energy and sleep from day-to-day, few studies have sought to identify factors that contribute to this daily variability. The present study extended previous research by employing a diary methodology among a large sample of CFS patients to examine whether daily variation in the satisfaction and frustration of the basic psychological needs for autonomy, competence, and relatedness would contribute to daily variation in fatigue and vitality. In addition, we also examined whether daily need experiences would be predictive of and predicted by daily variation in quality and quantity of sleep. The results revealed several interesting findings.

First, consistent with findings from previous diary studies (e.g., Kempke et al., 2012; Kempke et al., 2013), intercept-only models revealed that subjective energy fluctuated considerably from day-to-day, with results indicating that approximately 62% of the variance in both fatigue and vitality was situated at the daily level. This suggests that, rather than fatigue in CFS remaining stable over time as has been previously suggested (e.g., Jones, Gray, Frith, Newton, 2011), it displays short-term variability from day-to-day. Moreover, similar short-term daily fluctuations were reported in subjective vitality. Although it might be assumed that CFS patients' persistently lack vitality as a result of their enduring complaints of fatigue, the present results suggest that even when it comes to positive feelings of energy and aliveness, one day is not necessarily the same as the next. Apart from fluctuations in subjective energy, participants' also reported significant daily variation in their self-reported quality and quantity of sleep as well as in the satisfaction and frustration of their basic psychological needs. Overall, the finding that these constructs vary substantially from day-to-day further emphasizes the need for research to shed light on the factors that contribute to these short-term daily fluctuations in subjective energy, sleep and psychological need experiences in CFS.

Importantly, the present findings indicated that CFS patients' daily experiences of need satisfaction- and frustration contributed to daily fluctuations in their subjective energy. Specifically, the results revealed that on days that CFS patients' experienced more daily need satisfaction they reported less fatigue and more vitality whereas on days that patients' experienced higher frustration of their psychological needs they reported more fatigue and less vitality. Similar to previous findings in non-clinical populations (e.g., Ryan et al., 2010 Chen et al., 2015), these findings suggest that need satisfaction represents an important resource for energy, even among clinical populations who perceive their energy to be severely depleted. Although based on recent theorizing (Vansteenkiste & Ryan, 2013) and findings (e.g., Van der Kaap-deeder, 2016) we hypothesized that need satisfaction would be especially related to vitality and need frustration would be especially related to fatigue, the present findings only partially supported these hypotheses. While daily need satisfaction was more strongly related to daily vitality, both daily need satisfaction- and frustration displayed a similar strength relation with daily fatigue. Thus, the hypothesized differential role of need satisfaction- and frustration in the prediction of positive and negative indicators of energy was only supported with respect to daily vitality, whereas both low daily need satisfaction and high daily need frustration were implicated in daily fatigue. In other words, the absence of need satisfaction was enough for patients to report more fatigue, they did not necessarily need to encounter an active thwarting of their needs to feel depleted.

Daily need-experiences also related to CFS patients' daily sleep quality, with need frustration playing a prominent role. After days in which CFS patients' experienced frustration of their psychological needs they reported poorer sleep quality. However, daily need-based experiences were unrelated to daily fluctuations in self-reported sleep quantity. These findings are partially in line with findings from a recent prospective cross-sectional study among individuals with unexplained chronic fatigue (Campbell, Tobback et al., 2016) which similarly found no direct association between need frustration and sleep quantity. However, Campbell, Tobback et al. (2016) also found no direct association between need frustration and sleep quality but rather found need frustration to be indirectly related to both poorer quality and quantity of sleep through higher stress and negative sleep cognitions. Although these underlying mechanisms were not assessed in the present study, we speculate that stress and negative sleep cognitions may play a similar intervening role in CFS. In other words, after days in which CFS patients' feel socially isolated, pressured and ineffective in their activities, they may be more likely to experience symptoms of stress which in turn may feed into dysfunctional cognitions before sleep and when awakening throughout the night, which may interfere with their quality and quantity of sleep. Hence, future research should assess these possible intervening mechanisms.

In addition to examining whether daily need experiences would contribute to quality and quantity of sleep at night we also examined whether quality and quantity of sleep would contribute to daily need experiences. Following nights in which CFS patients' experienced higher sleep quality they reported more need satisfaction and lower need frustration throughout the following day. This suggests that higher quality sleep may provide CFS patients with some restoration which may facilitate their effective engagement in the activities that they value throughout the day. Overall, these results are suggestive of a possible bi-directional relationship between daily need frustration and daily poor sleep quality such that need frustration during the day contributed to poorer sleep quality at night and poorer sleep quality at night contributed to more need frustration throughout the following day. This suggests that when need frustrated, or after a night of poor sleep quality CFS patients may become trapped in a negative cycle of poor sleep and need frustration.

Limitations and Suggestions for Future Research

The present study has several limitations. Unfortunately, subjective energy was not assessed in the morning, which prevented us from examining whether morning reports of fatigue and vitality contributed to daily need experiences. Also, these findings do not allow us to draw conclusions about the direction of effects. Daily need frustration may not only contribute to but may also stem from daily fatigue. To address this issue of causality future experimental research is needed. Furthermore, subjective energy and need experiences were only assessed once a day. To obtain a better understanding of how these processes are related within the day, future diary studies could use an experience sampling method (Shiffman, Stone, & Hufford, 2008) and collect multiple assessments throughout the day. The exclusive use of self-reports to assess sleep may also have inflated the observed association between daily need frustration and daily sleep quality through shared method variance. Future research can try to overcome this problem by using objective measures of sleep such as polysomnography and determining how data derived from polysomnography can best be used to provide an objective indication of sleep quality. Future research should also examine the possible explanatory (i.e., mediating) role of stress and negative pre-sleep cognitions in the relation between need experiences and subjective energy and sleep. In addition, future studies could examine moderators of the daily relation between need experiences and subjective energy and sleep quality. For example, self-critical perfectionism (Blatt, 2004) and mindfulness (Brown & Ryan, 2003) could be examined as potential moderators as both have previously been shown to influence stress reactivity (e.g., Kempke, Luyten, Mayes, Van Houdenhove, Claes, 2015; Weinstein, Brown, Ryan, 2009), which is presumed to play an explanatory role in the observed need-energy/sleep quality association.

Theoretical and Practical Implications

The present study replicated previous findings by showing that there is significant variation within-patients from day-to-day in fatigue and sleep and extended previous findings by demonstrating that vitality and psychological need experiences also vary substantially from day-to-day in CFS. Moreover, the present results revealed that the previously identified association between basic psychological need experiences and subjective energy and sleep quality also extend to individuals with CFS and apply at the within-person level from day-to-day. Finally, to the best of our knowledge the present study is the first to examine the contributory role of poor sleep quality to psychological need experiences and demonstrate that following a night of poor quality sleep CFS patients' are likely to experience less need satisfaction and more need frustration throughout the day.

The present findings imply that healthcare professionals seeking to enhance energy and improve sleep quality in CFS patients' could incorporate a focus on basic psychological needs within their approach. For example, patients could be encouraged to identify and engage in small, manageable daily activities which satisfy their basic psychological needs (e.g., Weinstein, Khabbaz, & Legate, 2016). Patients' could also be helped to become more aware of sources of need frustration within their daily lives and to regulate their emotional reactivity to these experiences. Finally, it may also be important to foster psychological need satisfaction within the therapeutic relationship, by for example providing choice and minimizing pressuring strategies, responding in a warm and empathic manner and providing structure and manageable tasks (e.g., Teixeira et al., 2012).

Conclusion

The present findings emphasize the dynamic and fluctuating nature of subjective energy, sleep and psychological need experiences in CFS. The findings indicate that on days that CFS patients' feel a sense of choice and effectiveness in their activities and connect with significant others their energy is likely to be enhanced. Conversely, on days that CFS patients' feel pressured and ineffective in their activities and excluded by important others they are more likely to feel drained of energy and experience poor quality sleep at night. Results further suggest that after a night of poor quality sleep, CFS patients' are likely to feel incapable of carrying out valued daily activities and less able to connect with important others. Overall, the present results imply that need satisfaction represents an important resource for energy and better sleep quality among CFS patients and that poor sleep quality may create vulnerability for need frustration.

References

Bartholomew, K. J., Ntoumanis, N., Ryan, R. M., & Thogersen-Ntoumani, C. (2011). Psychological need thwarting in the sport context: Assessing the darker side of athletic experience. *Journal of Sport & Exercise Psychology, 33*, 75-102.

Blatt, S. J. (2004). *Experiences of Depression: Theoretical, Clinical and Research Perspectives*. Washinton, DC: American Psychological Association.

Boone, L., Vansteenkiste, M., van der Kaap-Deeder, J., Soenens, B., & Verstuyf, J. (2014). Self-critical perfectionism and binge eating symptoms: A longitudinal test of the intervening role of psychological need frustration. *Journal of Counseling Psychology, 61*, 363-73.

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology*, *84*, 822–848.

Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index – a new instrument for psychiatric practice and research. *Psychiatry Research*, *28*, 193–213.

Campbell, R., Tobback, E., Delesie, L., Vogelaers, D., Mariman, A., & Vansteenkiste, M. (2016). Basic psychological need experiences, fatigue and sleep in individuals with unexplained chronic fatigue. *Stress and Health.*

Campbell, R., Vansteenkiste, M., Delesie, L. M., Mariman, A. N., Soenens, B., Tobback, E., Van der Kaap-Deeder, J., & Vogelaers, D. P. (2015). Examining the role of psychological need satisfaction in sleep: A Self-Determination Theory perspective. *Personality and Individual Differences*, *77,* 199-204.

Campbell, R., Vansteenkiste, M., Delesie, L. M., Soenens, B., Tobback, E., Vogelaers, D., & Mariman, A. (2016). The role of psychological need satisfaction, sleep, and mindfulness in the health related quality of life of people living with HIV. *Journal of Health Psychology.*

Chen, B., Vansteenkiste, M., Beyers, W., Boone, L., Deci, E. L., Duriez, B. Lens, W., Matos, L., Mouratidis, A., Ryan, R. M., Sheldon, K. M., Soenens, B., Van Petegem, S., & Van der

Kaap-Deeder, J., & Verstuyf, J (2015). Basic psychological need satisfaction, need frustration, and need strength across four cultures. *Motivation and Emotion, 39,* 216-236.

Deci, E. L. & Ryan, R. M. (2000). The 'what' and 'why' of goal pursuits: Human needs and the self determination of behavior. *Psychological Inquiry*, *11*, 227-268.

Fukuda, K., Straus, S. E., Hickie, I., Sharpe, M. C., Dobbins, J. G., Komaroff, A., … Reeves, W. C. (1994). The chronic fatigue syndrome - a comprehensive approach to its defintions and study. *Annals of Internal Medicine*, *121*, 953-959.

Gotts, Z. M., Newton, J. L., Ellis, J. G., & Deary, V. (2016). The experience of sleep in chronic fatigue syndrome: A qualitative interview study with patients. *British Journal of Health Psychology*, *21*, 71-92.

Heijmans, M. J. W. M. (1998). Coping and adaptive outcome in chronic fatigue syndrome: Importance of illness cognitions. *Journal of Psychosomatic Research, 45,* 39-51.

Jones, D. E., Gray, J., Frith, J., & Newton, J.L. (2011). Fatigue severity remains stable over time and independently associated with orthostatic symptoms in chronic fatigue syndrome: a longitudinal study. *Journal of Internal Medicine*, 269, 182-188.

Kempke, S., Luyten, P., Claes, L., Goossens, L., Bekaert, P., Van Wambeke, P., & Van Houdenhove, B. (2012). Self-critical perfectionism and its relationship to fatigue and pain in the daily flow of life in patients with chronic fatigue syndrome. *Psychological Medicine,* 43, 995-1002.

Kempke, S., Luyten, P., Claes, S., Van Wambeke, P., Bekaert, P., Goossens, L., & Van Houdenhove, B. (2013). The prevalence and impact of early childhood trauma in chronic fatigue syndrome. *Journal of Psychiatric Research,* 47, 664-669.

Kempke, S., Luyten, P., Mayes, L.C., Van Houdenhove, B., & Claes, S. (2015). Self-critical perfectionism predicts lower cortisol response to experimental stress in patients with chronic fatigue syndrome. *Health Psychology*, *35*, 3, 298-307.

Monk, T. H., Reynolds, C. F., Kupfer, D. J., Buysse, D. J., Coble, P. A., Hayes, A. J., Machen, M. A., Petrie, S. R., & Ritenour, A. M. (1994). The Pittsburgh Sleep Diary. *Journal of Sleep Research, 3,* 111-120.

Milrad, S. F., Hall, D. L., Jutagir, D.r., Lattie, E.G., Ironson, G.H., Wohlgemuth, W., Nunez, M. V., Garcia, L., Czaja, S.J., Perdomo, D.M., Fletcher, M.A., Klimas, N., & Antoni, M.H. (2017). Poor sleep quality is associated with greater circulating pro-inflammatory cytokines and severity and frequency of chronic fatigue syndrome/myalgic encephalomyelitis (CFS/ME) symptoms in women. *Journal of Neuroimmunonology, 303,* 43-50.

Nisenbaum, R., Jones, J.F., Unger, E.R., Reyes, M., Reeves, W.C. (2003). A population-based study of the clinical course of chronic fatigue syndrome. *Health and Quality of Life Outcomes,1*:49.

Reis, H. T., Sheldon, K. M., Gable, S. L., Roscoe, J., & Ryan, R. M. (2000). Daily well-being: The role of autonomy, competence and relatedness. *Personality and Social Psychology Bulletin,* 26, 419-435.

Runyan, J., Steenbergh, T., Bainbridge, C., Daugherty, D., Oke, L., & Fry, B .(2013). A smartphone ecological momentary assessment intervention "App" for collecting real-time data and promoting self-awareness. *PLOS/one*.doi:10.1371/journal.pone.00713
25.

Russell, C., Wearden, A.J., Fairclough, G., Emsley, R.A., & Kyle, S.D. (2016). Subjective but not actigraphy-defined sleep predicts next-day fatigue in chronic fatigue syndrome: A prospective daily diary study. *Sleep, 39,* 937-944.

Ryan, R. M., Bernstein, J.H., & Brown, K.W. (2010). Weekends, work, and well-being: Psychological need satisfactions and day of the week effects on mood, vitality, and physical symptoms. *Journal of Social and Clinical Psychology,* 29, 95-122.

Ryan, R. M., & Deci, E. L. (2008). From ego depletion to vitality: Theory and findings concerning the facilitation of energy available to the self. *Social and Personality Psychology Compass*, 2/2, 702-717.

Ryan, R. M., & Frederick, C. M. (1997). On energy, personality, and health: Subjective vitality as a dynamic reflection of well-being. *Journal of Personality*, *65*, 529–565.

Schreurs, K. M. G., Veehof, M. M., Passade, L., & Vollenbroek-Hutten, M. M. R. (2011). Cognitive behavioral treatment for chronic fatigue syndrome in a rehabilitation setting: Effectiveness and predictors of outcome. *Behavior and Therapy, 49,* 908-913.

Shiffman, S., Stone A., & Hufford, M. (2008). Ecological momentary assessment. *Annual Review of Clinical Psychology* 4:1–32.

Teixeira, P.J., Carraca, E.V., Markland, D., Silva, M.N., & Ryan, R.M. (2012). Exercise, physical activity, and self-determination theory: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity, 9,* 78.

Van den Broeck, A., Vansteenkiste, M., De Witte, H., Lens, W. (2008). Explaining the relationships between job characteristics, burnout, and engagement: The role of basic psychological need satisfaction. *Work & Stress, 22,* 277-294.

Van Hooff, M. L. M., & Geurts, S. A. E. (2014). Need satisfaction during free evening hours: Examining its role in daily recovery. *Stress and Health, 30,* 198 – 208.

Van der Kaap-Deeder, J., Vansteenkiste, M., Soenens, B., & Mabbe, E. (2016). Children’s daily well-being: The role of mothers’, teachers’, and siblings’ autonomy support and psychological control. *Developmental Psychology*.

Vansteenkiste, M., & Ryan, R. M. (2013). On psychological growth and vulnerability: Basic psychological need satisfaction and need frustration as a unifying principle. *Journal of Psychotherapy Integration, 23,* 263-280.

Verspaandonck, J., Coenders, M., Bleijenberg, G., Lobbestael, J., Knoop, H. (2015). The role of the partner and relationship satisfaction on treatment outcome in patients with chronic fatigue syndrome. *Psychological Medicine, 45,* 2345-2352.

Watson, D., O’Hara, M. W., Simms, L. J., Kotov, R., & Chmielewski, M. (2007). Development and validation of the Inventory of Depression and Anxiety Symptoms (IDAS). *Psychological Assessment*, *19*, 253–268.

Weinstein, N., Brown, K. W., & Ryan, R.M. (2009). A multi-method examination of the effects of mindfulness on stress attribution, coping, and emotional well-being. *Journal of Research in Personality*, *43*, 374–385.

Weinstein, N., Khabbaz, F., & Legate, N. (2016). Enhancing need satisfaction to reduce psychological distress in Syrian refugees. *Journal of Consulting and Clinical Psychology* PMID 27018533.

Examining Daily Variation in Adolescent Sleep: The Role of Psychological Need Experiences[1]

Adolescents are particularly vulnerable for poor sleep and display considerable variability in quality and quantity of sleep from day-to-day. However, few studies have identified psychological processes that contribute to this daily variation. In the present research two diary studies to examined the reciprocal association between adolescents' daily experiences of the satisfaction and frustration of their basic psychological needs for autonomy, competence, and relatedness, and their daily quality and quantity of sleep. The role of stress in these reciprocal day-to-day associations was also examined. Results from Study 1 (N = 211; 52% female; Mage = 15.86, SD = 1.18) indicated that daily need frustration related to more daily fatigue and poorer daily sleep quality and shorter self-reported sleep quantity. Furthermore, poorer daily sleep quality and shorter daily sleep quantity also related to more need frustration and less need satisfaction throughout the following day. Study 2 (N = 51; 49% female; Mage = 15.88, SD = 2.88) replicated and extended these findings by demonstrating that daily need frustration also related to shorter objective daily sleep quantity, as measured by actigraphy. Study 2 further provided evidence for the explanatory role of (a) symptoms of stress in the relation between daily need frustration and the daily sleep-related outcomes and (b) daily need frustration in the relation between previous night's sleep quality and symptoms of stress, as reported the following day. Overall, these findings underscore the dynamic interplay between daily need experiences and adolescent quality and quantity of sleep.

[1] Campbell R., Vansteenkiste, M., Soenens, B., Vandenkerckhove, B., & Mouratidis, A. (2017). Examining daily variation in adolescent sleep: The role of psychological need experiences. *Manuscript submitted for publication.*

Introduction

Adolescence marks a developmental period in which various biological and psychosocial factors conspire to put adolescents at risk for poor sleep (Becker, Langberg, & Byars, 2015). Early school start times conflict with a biologically driven circadian phase delay that leads adolescents to prefer later bed and wake times (Dahl & Lewin, 2002), a problem which is further compounded by high academic and extracurricular demands outside of school hours (Miller, Danner, & Staten, 2008; Roberts, Roberts & Xing, 2011; Zhou et al., 2012). As a result, sleep disturbances in adolescence are highly prevalent and up to 36% of adolescents worldwide are estimated to suffer from sleep difficulties (Gradisar, Gardner, & Dohnt, 2011). These high prevalence rates are troubling, given that poor sleep in adolescence has been linked to numerous adverse outcomes, including poor academic functioning, mental health problems (e.g., depressive symptoms and low self-esteem), and increased risk for substance use (for an overview see Shochat, Cohen-Zen, Tzischinsky, 2014).

The pervasiveness and negative impact that poor sleep can have on adolescent functioning highlights the need for research to identify predictors of adolescent sleep. Many previous studies have addressed sources of between-person differences in sleep, including for example, time spent on homework (Zhou et al., 2012) or hours spent in part-time employment (Miller et al., 2008). However, diary studies (e.g., Fuligni & Hardway, 2006; Doane & Thurston, 2014) indicate that there is striking within-person (i.e., day-to-day) variability in adolescent sleep. Despite such findings, relatively few studies have identified psychological processes and factors that contribute to such day-to-day variability in adolescent quality and quantity of sleep. The present research, grounded in Self-Determination Theory (SDT; Ryan & Deci, 2017), aimed to examine the day-to-day covariation between experiences of the satisfaction and frustration of the basic psychological needs for autonomy, competence, and relatedness and adolescent sleep-related outcomes. Need-based experiences are likely candidates to account for within-person variability in sleep because these experiences themselves fluctuate substantially from day-to-day (Ryan, Bernstein, & Brown, 2010). Moreover, because these needs are amenable to change they represent potential targets for intervention and prevention efforts (e.g., Weinstein, Khabbaz, & Legate, 2016) seeking to improve adolescent sleep.

Self-Determination Theory: Basic Psychological Needs

SDT (Deci & Ryan, 2000; Ryan & Deci, 2017) is a broad theory of human behavior and personality development which delineates the necessary conditions for human thriving. Central to SDT is the identification of three inherent and universal basic psychological needs. The need for *autonomy* refers to experiencing a sense of volition and self-endorsement in one's behavior, the need for *competence* refers to feeling capable of achieving desired outcomes, and the need for *relatedness* refers to experiencing a sense of reciprocal care and closeness with important others. Within SDT, the satisfaction of these needs is claimed to be essential for psychological growth and well-being, whereas the active frustration of these needs is said to undermine individuals' functioning and bring about maladaptive outcomes (Vansteenkiste & Ryan, 2013). When these needs are frustrated, people experience pressure to think feel or act a certain way (autonomy frustration), as well as failure and inadequacy (competence frustration), and rejection and social exclusion (relatedness frustration).

Supporting SDT's claims, ample previous research has shown the satisfaction of these basic psychological needs to be associated with a host of adaptive outcomes. For example, when these psychological needs are satisfied people report feeling more energized (i.e., subjective vitality; Deci & Ryan, 2008), having higher self-esteem and being more satisfied with their lives in general (i.e., life satisfaction; Deci & Ryan, 2000). Associations between need satisfaction and indicators of wellness have emerged across diverse life domains (e.g., work, education, sport, & healthcare) and cultures (e.g., Chen et al., 2015).

Importantly, while low need satisfaction can hamper psychological well-being, recent research increasingly indicates that the active frustration of psychological needs is especially damaging and a more robust predictor of ill-being. For example, studies have shown psychological need frustration to be uniquely predictive of symptoms of anxiety and somatization (Cordeiro, Paixão, Lens, Lacante, & Luyckx, 2016) as well as depressive symptoms and exhaustion

(Bartholomew, Ntoumanis, Ryan, Bosch, and Thørgensen-Ntoumanis et al., 2011), over and above a lack of need fulfillment.

While much of this previous research was carried out among adults, several studies have also begun to demonstrate the importance of these psychological needs for adolescents' adjustment. Specifically, previous studies indicate that need satisfaction contributes to adolescents' well-being and resilience (Emery, Toste, & Heath, 2015; Veronneau, Koestner, & Abela, 2005), whereas need frustration poses risk for distress and problem behaviors (Costa, Cuzzocrea, Gugliandolo, & Larcan, 2016; Mabbe, Soenens, Vansteenkiste, & Van Leeuwen, 2016).

Furthermore, need-based experiences have also been shown to vary substantially from day to day, with daily variation in need experiences predicting daily variation in well-being (Ryan et al., 2010). Surprisingly, few studies to date have examined daily fluctuations in adolescents' need experiences (see Verstuyf et al., 2013 for an exception). This is unfortunate because adolescents display more daily variation in emotions and interaction patterns compared to both younger children and adults (Granic, Hollenstein, Dishion, & Patterson, 2003; Larson, Moneta, Richards, & Wilson, 2002; Maciejewski, Lier, Branje, Meeus, & Koot, 2015). Accordingly, it is likely that adolescents will display considerable ups and down in need experiences on a daily basis, which could have potential implications for their sleep.

Basic Psychological Needs and Sleep

Apart from these basic psychological needs being robustly related to indicators of well-being (when satisfied) and ill-being (when frustrated), a few studies also suggest that they play a role in the (dys)regulation of physiological needs such as sex (Smith, 2007) and eating behavior (Boone, Vansteenkiste, Soenens, van der Kaap-Deeder, & Verstuyf, 2014). Importantly, psychological needs have also been implicated in individuals' sleep quantity, which refers to the total amount of time an individual sleeps per night, as well as individuals' sleep quality, which typically refers to a subjective appraisal of the quality or restoration provided by sleep. For example, one study examining between-person differences among healthy adults found that individuals who experienced higher need satisfaction during the past month also reported better sleep quality, less daytime dysfunction (as indexed by higher vitality and lower fatigue) and somewhat longer sleep duration (Campbell et al., 2015). Similarly, another cross-sectional study demonstrated need satisfaction to be related to better sleep quality among HIV patients (Campbell et al., 2016). Of particular relevance to the present study, a recent diary study among patients with Chronic Fatigue Syndrome (CFS), who are particularly at risk for poor sleep, demonstrated that daily need frustration preceded poorer quality sleep at night (Campbell et al., 2017). Together, these previous findings indicate that need-based experiences relate to diverse sleep outcomes, and suggest that their relation with sleep quality in particular is more pronounced. This is important given that previous research indicates that sleep quality is more strongly related to physical and mental health than sleep quantity (e.g., Campbell et al., 2016; Pilcher, Ginter, Sadowsky, 1997; Pilcher, Schoeling, & Prosansky, 2000). However, despite previous evidence suggesting that psychological need experiences may contribute to day-to-day variability in sleep quality in particular, no studies have yet examined whether these within-person associations also extend to adolescent populations.

A few previous studies provide indirect support for the hypothesized day-to-day (i.e. within-person) association between SDT's basic psychological needs and sleep-related outcomes among adolescents. For example, a diary study among adolescents (aged 14–15), found that higher daily academic demands were associated with less self-reported sleep at night (Fuligni & Hardway, 2006), whereas another diary study among first year university students (aged 17-19) demonstrated that expecting to take a test the next day was associated with shorter self-reported sleep quantity (Galambos, Dalton, Maggs., 2009). Indeed, high academic demands and expecting to take a test the next day may be accompanied by feelings of both autonomy and competence frustration because some adolescents might feel pressured to do their school work (e.g., by their teachers or parents) at the expense of engaging in other "more fun" activities, and may also have doubts about their capabilities to meet external requirements and to achieve desired grades (see Krijgsman et al., in press). In addition, there is also evidence to suggest that experiences of relatedness are implicated in daily variability in adolescent sleep. For example, Galambos et al (2009) demonstrated that socializing with friends during the day was associated with longer self-reported sleep duration.

Furthermore, another diary study utilizing objective measures of sleep, found that adolescents (age 17 – 18) higher in trait loneliness slept less across a three-day study period (Doane & Thurston, 2014). Although these studies did not directly assess SDT's basic psychological needs, together they provide indirect evidence for the hypothesis that experiences of the satisfaction and frustration of psychological needs may be implicated in the day-to-day variability in adolescent sleep.

Of course, it is equally plausible that daily need experiences not only precede but may also follow from sleep at night. Indeed, previous diary studies among adolescents provided evidence for the role of daily quality and quantity of sleep in contributing to daily experiences. For example, Fuligni and Hardway (2006) found that shorter self-reported sleep duration was related to more fatigue and feelings of anxiety and depressive symptoms throughout the following day. In addition, Galambos et al., (2009) found that less self-reported sleep at night contributed to more negative affect and less socializing with friends the next day, whereas poorer subjective sleep quality was related to less negative affect and more positive affect.

Much like sleep affects adolescents' emotions, sleep is also likely to influence adolescents' need-based experiences. Because of sleep's restorative and energizing properties, after a night of sufficient, good quality sleep, adolescents may be more able to engage in and select need-satisfying activities and be more equipped to handle any encountered need frustrating experiences. Thus, we propose that daily experiences of the satisfaction and frustration of basic psychological needs are likely to be reciprocally related to the physical need for sleep. Hence, in addition to daily need experiences contributing to sleep at night, sleep at night is also likely to be predictive of the satisfaction or frustration of basic psychological needs.

The Role of Stress

In addition to examining the reciprocal day-to-day association between need experiences and sleep, a second main objective of the present research was to examine processes that account for (i.e., explain) the hypothesized need-sleep relation. In the present research we propose that symptoms of stress such as tension and arousal (Lovibond & Lovibond, 2004) are likely to play an explanatory role in these day-to-day associations. This is because symptoms of stress likely arouse adolescents to a level that makes it difficult to relax at night, thereby obstructing restful sleep. In support of this view, a longitudinal study found that older adolescents (aged 17-19) reported poorer sleep quality and shorter sleep duration in months that they experienced higher stress (Galambos, Howard, & Maggs, 2010). In addition, diary studies have shown perceived stress during the day to be predictive of shorter subjectively reported (Fuligni & Hardway, 2006) and objectively recorded (Doane & Thurston, 2014) sleep duration. Furthermore, adolescent sleep has also been shown to predict next day levels of stress, with poor sleep quality (Galambos, Dalton, & Maggs, 2009) and shorter objective sleep quantity (Doane & Thurston, 2014) relating to higher stress throughout the following day.

Although previous research suggests that daily stress is detrimental to adolescent sleep, no studies have yet identified specific factors within the day which contribute to this day-to-day variability in stress and in turn poor sleep. In the present research, we propose that on days that adolescents experience low satisfaction or even frustration of their basic psychological needs and thus feel pressured and ineffective in their activities and rejected by important others, they are likely to experience more symptoms of stress (e.g., tension and arousal). In turn, stress likely obstructs both the quality and quantity of their sleep at night. Conversely, because adolescents are likely to feel depleted after a night of poor quality and insufficient sleep, they may struggle to carry out valued everyday activities, including socializing with friends thus increasing the likelihood that they will experience need frustration. This need frustration in turn is likely to elicit symptoms of stress throughout the day. So again, we predict that associations between the needs, stress, and sleep are reciprocal in nature.

In line with this reasoning several previous studies (conducted mainly with adults) suggest that basic psychological needs are involved in stress reactivity with psychological need frustration in particular being associated with experienced stress (for an overview see Weinstein & Ryan, 2011). For example, a recent study among individuals with unexplained chronic fatigue demonstrated that participants who experienced more need frustration during the past week, reported more symptoms of stress and negative sleep-related thoughts, which in turn contributed to poorer quality and quantity of sleep during a stay at a sleep laboratory (Campbell, Tobback et al., 2017). Furthermore, a short-term longitudinal study with college students found that increases in psychological need frustration related to increases in symptoms of stress, which in turn related to deterioration in quality and quantity of sleep (Campbell, Vansteenkiste et al., 2017). However, no studies have yet examined the intervening role of stress in the relation between daily psychological need experiences and adolescent quality and quantity of sleep, or whether psychological need frustration helps to explain why it is that adolescents report more stress after a night of poor sleep.

Present Research

The global objective of the present research was to examine the day-to-day association between psychological need experiences and quality and quantity of sleep and daytime fatigue among adolescents. We deemed it important to include fatigue as a sleep-related outcome because measures commonly used to assess sleep (i.e., the Pittsburgh Sleep Quality Index; Buysse et al., 1987) typically assess not only qualitative and quantitative aspects of sleep but also more daytime-related indicators of energy and exhaustion. To investigate these dynamic associations we conducted two diary studies. This allowed for the close examination of lived day-to-day experiences in a natural context, thereby increasing the ecological validity of the findings. Furthermore, because participants provided assessments every day, measurement error due to biased retrospective recall was minimized (Bolger et al., 2003).

Given the lack of previous studies examining the role of need experiences in contributing to adolescent sleep and vice versa, our first main objective was to examine the hypothesized reciprocal need-sleep dynamics at the within-person level (i.e., from day to day). Specifically, in both studies we examined whether daily need experiences would be predictive of as well as predicted by quality and quantity of sleep at night. In Study 1 we began by examining these associations using daily self-reports. However, given that a sole reliance on self-reports can inflate associations due to shared method variance, in Study 2 we sought to overcome this problem by assessing sleep objectively using wrist actigraphy. The second key objective of the present research was to examine the explanatory role of stress in the day-to-day association between psychological need experiences and the sleep-related outcomes. This objective was pursued in Study 2 by examining whether symptoms of stress would account for (i.e., explain) the day-to-day association between psychological need experiences and sleep and fatigue. In addition, given that need experiences, stress and sleep are likely to be reciprocally related, in Study 2 we also examined whether psychological need experiences would play an explanatory role in the association between daily quality and quantity of sleep and next day symptoms of stress.

Study 1

In Study 1 we tested two hypotheses. First, we examined whether day-to-day variability in need satisfaction and need frustration would be related to daily variation in daytime fatigue and quality and quantity of sleep at night (Hypothesis 1). We hypothesized that adolescents who encounter more need frustrating experiences during the day would report poorer quality and shorter quantity of sleep at night, because these negative experiences would likely elicit emotional and physiological arousal, which would obstruct restful sleep at night. The opposite pattern was expected for daily need satisfaction, which may facilitate better quality and quantity of sleep at night. We also expected daily need frustrating experiences to drain adolescents of energy and as a result to be related to more daily fatigue, whereas daily need satisfaction would likely be conducive to energy levels, thereby being related to less daily fatigue.

Second, we examined whether night-to-night variability in quality and quantity of sleep would contribute to adolescents' need experiences the following day. We expected poorer daily quality and shorter daily quantity of sleep to contribute to more experiences of daily need frustration and less experiences of daily need satisfaction (Hypothesis 2). We hypothesized that the restoration and energy that sufficient quality and quantity of sleep provides would not only enable adolescents to be more aware of and receptive to cues for psychological need satisfaction throughout the day, but would also enable them to pro-actively engage in need-satisfying activities, while avoiding and being more able to effectively handle need frustrating experiences.

Method

Participants and Procedure

Participants were 211 Belgian adolescents (52% female, *M* age = 15.86 years, *SD* = 1.18, range 13 – 18). All participants were enrolled in a secondary education with 64% following a general academic track, 27% following a technical track, 7% following a vocational track and 2% following an artistic track.

All participants were recruited by second year bachelor students from the host University as part of an undergraduate course in Developmental Psychology. All bachelor students were asked to recruit two adolescents for the study and received clear instructions regarding the recruitment procedure. Participants were visited at their home, during which the requirements of the study were explained and written informed consent was obtained from all participants as well as from their parents. Participation in the study was voluntary and confidential treatment of the data was guaranteed. During the first home visit, participants received a booklet with daily questionnaires which they were asked to fill in twice a day for 8 consecutive days; once in the evening directly before going to bed and once in the morning directly after waking up. All participants completed the diaries on the same days of the week, from a Monday to a Monday and were sent daily reminders in the form of an e-mail or text message in order to stimulate ongoing completion of the diaries. During a second home visit, the diaries were collected by the bachelor students who then returned them to the researchers. The procedure was carried out conform to the ethical guidelines at the host institute.

Daily Measures

Evening Measures

Daily Psychological Need Satisfaction and Need Frustration. The daily satisfaction and frustration of the basic psychological needs for autonomy, competence and relatedness was assessed using the Balanced Measure of Psychological Needs (BMPN; Sheldon & Hilpert, 2012). The scale consists of 18 items, 6 items per need, 3 of which tap into need satisfaction and 3 of which tap into need frustration and was adapted so that it assessed experiences during the past day. All participants rated on a scale of 1 (*not at all true*) to 5 (*very true*) as to whether they felt their need for autonomy (e.g., “Today the activities that I engaged in were based on my true interests and values” or “Today I had a lot of pressures I could do without”), competence (e.g., “Today I successfully completed difficult tasks and projects” or “Today I experienced some kind of failure, or was unable to do well at something”) and relatedness (e.g., “Today I felt close and connected to the people who are important to me” or “I was lonely”) were satisfied or frustrated during the past day. Two composite scores were created by averaging the 9 items assessing daily need satisfaction (average α = .83; range across days = .77 - .87) and by averaging the 9 items assessing daily need frustration (average α = .77; range across days = .73 - .84). While the main analyses focus on the total scores of need satisfaction and need frustration, for descriptive purposes we will also provide correlations between the satisfaction and frustration of each of the separate needs with the sleep variables. Satisfaction of the needs for autonomy, competence and relatedness had average reliabilities of .74 (range across days = .65-.78), .71 (range across days = .59-.78) and .83 (range across days = .70-.89), respectively, whereas their frustration had reliabilities of .63 (range across days = .59-.70), .69 (range across days = .65 - .79) and .61 (range across days = .56 – .67), respectively.

Daily Fatigue. Daily fatigue was assessed using the lassitude subscale from the Inventory of Depression and Anxiety Symptoms (IDAS; Watson et al., 2007). The 6-item scale was adapted to assess symptoms of fatigue experienced during the past day (e.g., “Today I felt sleepy and drowsy”). All items were rated on a 5-point Likert scale ranging from 1 (*not at all*) to 5 (*very much so*). The scale had an average reliability of .84; range across days = .80 - .88.

Morning Measures

Daily Sleep Quality. Daily sleep quality was assessed using a visual analogue scale (VAS) from the Pittsburgh Sleep Diary (Monk et al., 1994). All participants rated a VAS which assessed their previous night’s sleep quality (i.e., “How was your sleep quality last night?”) on a scale from 0 (*extremely poor* or *not at all*) to 100 (*extremely good* or *very much so*).

Daily Sleep Quantity. Daily sleep quantity was calculated using four open-ended questions from the Pittsburgh Sleep Diary (Monk et al., 1994) which assessed evening bed-time, morning wake-time, number of minutes it took to fall asleep (sleep latency) and the number of minutes spent awake during the night after initial sleep onset (wake after sleep onset). Total time in bed was calculated on the basis of the bed and wake times. Daily sleep duration was then calculated by subtracting sleep latency and wake after sleep onset from the total time spent in bed.

Plan of Analysis

As this study involved repeated measurements on 8 consecutive days (i.e., Level 1) nested within 211 adolescents (i.e., Level 2), multilevel analyses were performed using HLM software in order to take both between- and within-person differences into account. All predictor variables at Level 1 were group-mean centered (i.e., centered around the person's mean) and all predictor variables at Level 2 were centered around the grand mean. The only exception was gender which was uncentered (0 = males; 1 = females), such that the intercept represented the mean of the dependent variables for males. There were 15% missing values in the data. Because the morning measures were not assessed on the first day (i.e., sleep quality & sleep quantity) while the evening measures were not measured on the last day (i.e., need satisfaction, need frustration & fatigue) the models that involved these values were treated as structural missing values (i.e., listwise deletion) by HLM software.

Prior to investigating our main hypotheses, we began by examining whether there was significant day-to-day variability in the study variables by estimating intercept-only models without any explanatory variables. These models decompose the total variation in each outcome into variation at the between- and the within-person level. Then, to examine whether daily experiences of need satisfaction and need frustration would contribute to daily quality and quantity of sleep and daytime fatigue three separate models were tested (i.e., one for each outcome). In each model composite scores of daily need satisfaction and need frustration (i.e., at Level 1) were entered simultaneously as predictors of the daily outcomes (i.e., sleep quality, sleep quantity & fatigue; Hypothesis 1). Next, in a second set of models we examined whether day-to-day variability in quality and quantity of sleep, as reported in the morning, would contribute to experiences of need satisfaction and need frustration throughout the day. This was examined by entering morning reports of subjective sleep quantity and sleep quality simultaneously (i.e., at Level 1) as predictors of daily need satisfaction and need frustration as assessed in the evening (Hypothesis 2). Background characteristics (i.e., age and gender) were included as between-person predictors (i.e., at Level 2) in all models.

Results

Preliminary Analyses

Within-person correlations. The means, standard deviations and within-person (i.e., day-to-day) correlations between all of the daily measures are shown in Table 1. The composite score of daily need satisfaction was negatively related to daily fatigue and positively related to daily quality and quantity of sleep, whereas the composite score of daily need frustration was related to these variables in the opposite direction. The three separate need satisfactions and need frustrations (i.e., for autonomy, competence and relatedness) were moderately to strongly correlated within one another and displayed a similar pattern of relations with the study variables. Because of this similarity in associations with the sleep variables and to limit the number of models to be tested (in order to avoid Type I errors), the main analyses will rely on the composite scores of need satisfaction and frustration.

Background variables. To examine the relation between the adolescents' background characteristics and the study variables all daily measures were aggregated across the 8 days. Then, a MANCOVA was performed with gender as a fixed factor, age as a covariate and all study variables as dependent variables. Gender did not yield a significant multivariate effect ($F[5, 203] = 1.81$, *ns*), whereas age did (F $[5, 203] = 3.30$, $p < .01$, $\eta^2 = .08$). Subsequent univariate analyses indicated that age was positively related to need frustration ($F[1, 207] = 4.76$, $p <.05$, $\eta^2 = .02$), and negatively related to both daily quality $F[1, 207] = 4.00$, $p <.05$, $\eta^2 = .02$) and quantity $F[1, 207] = 12.62$, $p <.01$, $\eta^2 = .06$) of sleep.

Table 1

Means, Standard Deviations, Intra-class Correlations and Within-Person Correlations between Study Variables – Study 1

	1	2	3	4	5	6	7	8	9	10	11
1. Need satisfaction	-										
2. Autonomy satisfaction	.83***	-									
3. Competence satisfaction	.76***	.50***	-								
4. Relatedness satisfaction	.76***	.44***	.34***	-							
5. Need frustration	-.25***	-.28***	-.10***	-.20***	-						
6. Autonomy frustration	-.17***	-.25***	-.04	-.10***	.83***	-					
7. Competence frustration	-.19***	-.19***	-.11***	-.14***	.78***	.51***	-				
8. Relatedness frustration	-.23***	-.21***	-.10***	-.23***	.77***	.41***	.39***	-			
9. Fatigue	-.20***	-.23***	-.14***	-.11***	.43***	.36***	.37***	.30***	-		
10. Subjective sleep quality	.15***	.14***	.09***	.11***	-.20***	-.13***	-.16***	-.18***	-.12***	-	
11. Subjective sleep quantity	.08***	.10***	.06**	.02	-.13***	.12***	-.11***	-.07**	-.06**	0.20***	-
Mean	3.36	3.24	2.99	3.84	1.97	2.19	1.84	1.88	2.21	67.31	501.86
SD	.73	.97	.88	.96	.70	.95	.79	.89	.94	26.36	94.31
ICC	.48	.33	.42	.46	.51	.41	.43	.39	.27	.32	.14

Note. **p*<.05,***p* < .01, *p****<.001

Intra-class correlations (ICC'S). The ICC values for each study variable are also displayed in Table 1. With regard to fatigue and the sleep outcomes the ICC values indicated that a significant proportion of the variance in these variables was situated at the within-person level, with subjective sleep quantity displaying the most variance within-individuals (i.e., approx. 86%) and subjective sleep quality displaying the least amount of variance within-individuals (i.e., approx. 68%). With regard to need-based experiences ICC values indicated that approximately 52% and 49% of the variance in need satisfaction and need frustration, respectively, was situated within-individuals (i.e., from day-to-day). Thus, overall these results revealed considerable fluctuations in the study variables across the 8 day period, justifying our multilevel analytical approach.

Primary Analyses

Hypothesis 1: The role of daily psychological need experiences in predicting daily fatigue and sleep. As shown in Table 2 (i.e., models 1a to 1c), daily need satisfaction was negatively related to daily fatigue and positively related to daily sleep quantity but unrelated to daily sleep quality. Daily need frustration, in contrast, was positively related to daily fatigue and negatively related to both daily quantity and quality of sleep.

In a next set of models (i.e., Table 2; models 2a to 2c), we performed a more conservative test of our hypotheses by examining whether daily need satisfaction and daily need frustration would contribute to a change in daily fatigue and daily quality and quantity of sleep by controlling for the previous day level of each outcome. Overall, results of these more conservative analyses indicated that all within-day associations remained significant with one exception, namely, the day-to-day relation between need satisfaction and sleep quantity became non-significant.

Hypothesis 2: The role of daily sleep quantity and daily sleep quality in predicting next-day need experiences. Next, we examined whether daily variation in quality and quantity of sleep would contribute to next-day variability in experiences of need satisfaction and need frustration. As shown in Table 3 (i.e., Models 1a and 1b) morning reports of the previous nights' sleep quantity were positively related to daily need satisfaction and negatively related to daily need frustration. Similarly, previous the previous nights' sleep quality which was also negatively related

Table 2

Daily Fatigue, Sleep Quantity & Sleep Quality as a Function of Daily Need Satisfaction & Need Frustration – Study 1

	Fatigue				Sleep quantity				Sleep quality			
	Model 1a		Model 2a		Model 1b		Model 2b		Model 1c		Model 2c	
Fixed Effects	*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*
Intercept	2.06	(0.05)	2.07	(0.05)	503.18	(5.19)	503.17	(5.19)	59.12	(1.58)	60.17	(1.64)
Within-person predictors												
Need satisfaction	-0.18**	(0.05)	-0.18**	(0.05)	4.29	(5.72)	4.35	(5.71)	1.54	(0.83)	1.86	(1.33)
Need frustration	0.39**	(0.06)	0.38**	(0.06)	-30.55**	(6.35)	-30.45**	(6.31)	-4.73**	(1.38)	-3.91*	(1.59)
Previous day covariate	-	-	0.07[06]	(0.04)	-	-	0.01	(0.03)	-	-	-0.04	(0.04)
Between-person predictors												
Age	0.06	(0.04)	0.06	(0.03)	-10.76**	(3.09)	-10.80**	(3.09)	-0.71	(0.95)	-0.66	(0.98)
Gender	0.24**	(0.08)	0.24**	(0.08)	-4.18	(6.90)	-4.24	(6.92)	0.36	(2.08)	0.18	(2.15)

Random effects	Variance components					
Intercept	0.26**	0.26**	1415.89**	1416.86**	182.91**	189.16**
Covariate	-	-	-	-	-	-
Needs satisfaction	-	-	-	-	71.55**	64.84*
Needs frustration	0.16**	0.16**	1299.19	1281.48*	99.28**	126.24**
Level 1 Residuals	0.52	0.52	6528.91	6539.23	244.04	245.10

Note. *p<.05, **p < .01 Coefficients shown are unstandardized coefficients. In Model 1 previous day levels of the outcome were not controlled for. In Model 2 previous day levels of the outcome were controlled for. All a models examine fatigue as an outcome, b models examine sleep quantity as an outcome and c models examine sleep quality as an outcome

Table 3

Daily Need Satisfaction & Need Frustration as a Function of Daily Sleep Quality & Sleep Quantity – Study 1

	Need satisfaction				Need frustration			
	Model 1a		Mode 2a		Model 1b		Model 2b	
Fixed Effects	*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*
Intercept	3.36	(0.04)	3.39	(0.06)	1.88	(0.05)	1.88	(0.05)
Within-person predictors								
Sleep quantity	0.0056*	(0.0003)	0.0005*	(0.0003)	-0.0008*	(0.0002)	-0.0009**	(0.0002)
Sleep quality	0.0007	(0.0009)	0.0758*	(0.0377)	-0.0019*	(0.0009)	-0.0898*	(0.0349)
Previous day covariate	-	-	-0.12**	(0.04)			-0.02**	(0.04)
Between-person predictors								
Age	-0.03	(0.04)	-0.04	(0.04)	0.06	(0.03)	0.06[06]	(0.03)
Gender	0.00	(0.08)	0.02	(0.08)	0.15*	(0.08)	0.10	(0.07)

Random effects	Variance components			
Intercept	0.28**	0.29**	0.25**	0.25**
Covariate	-	-	-	0.05*
Sleep quantity	0.00001*	0.00001*	-	0.0001**
Sleep quality	-	-	0.00004**	-
Level 1 residuals	0.27	0.28	0.21	0.20

Note. **p*<.05, ***p* < .01 Coefficients shown are unstandardized coefficients. In Model 1 previous day levels of the outcome were not controlled for. In Model 2 previous day levels of the outcome were controlled for. Models a examine need satisfaction as an outcome, models b examine need frustration as an outcome to daily need frustration but was unrelated to daily need satisfaction. A next set of models revealed that after controlling for previous day levels of need experiences (i.e., Table 3; Model 2a & 2b), all initially observed associations remained significant. Furthermore, these subsequent models revealed that the relation between previous nights' sleep quality and daily need satisfaction became significant after controlling for the previous day levels of need satisfaction, suggesting that day-to-day variation did contribute to change in need satisfaction across days.

Brief Discussion

The results from Study 1 suggest that day-to-day variation in need experiences contributes to day-to-day variability in adolescents' fatigue and quality and quantity of sleep. Daily need frustration in particular was found to play a prominent role as it not only related to more daily fatigue, but also related to poorer daily sleep quality and shorter daily sleep quantity, even after controlling for these outcomes the previous day. Results further indicated that daily need-based experiences were not only predictive of, but were also predicted by daily quality and quantity of sleep. Specifically, longer sleep quantity, as reported in the morning, related to more experiences of need satisfaction and less experiences of need frustration throughout the day, whereas morning reports of poor sleep quality related to more daily experiences of need frustration. Overall, these results indicate that daily quality and quantity of sleep relate to need-based experiences and that their relation with experiences of need frustration in particular may be bi-directional.

Study 2

A second diary study aimed to build on findings from Study 1 in two important ways. The first way we aimed to build on findings from Study 1 was by assessing sleep quantity objectively from day-to-day using actigraphy. Actigraphy is a device worn on the wrist which measures movement and thereby allows for the differentiation between probable wake and sleep states. The data derived from actigraphy enabled us to examine whether the day-to-day association between need-based experiences and self-reported sleep observed in Study 1 would also hold when assessing sleep quantity objectively. We deemed this important, because adolescents' self-reports of sleep duration are subject to misperception and tend to overestimate total sleep time (e.g., Tremaine, Dorrian, & Bluden, 2010).

Second, we further aimed to extend findings from Study 1 by examining whether daily variation in perceived stress would account for the observed day-to-day associations between need experiences and sleep and fatigue. Based on recent theorizing (Vansteenkiste & Ryan, 2013) and empirical findings (Campbell, Tobback et al., 2017; Van der Kaap-Deeder, Vansteenkiste, Soenens, & Mabbe, 2016), we hypothesized that on days that adolescents experience more need frustration in particular, they would report more symptoms of stress, which in turn would likely erode energy levels and contribute to more daytime fatigue. In addition, stress is also likely to obstruct sleep at night and hence relate to poorer sleep quality and shorter sleep quantity (Hypothesis 1). Further, we also aimed to examine whether daily quality and quantity of sleep would contribute to daily need experiences and, in turn, symptoms of stress. We hypothesized that after nights of poorer sleep quality and shorter sleep duration, adolescents would experience less need satisfaction and more need frustration throughout the day, which in turn, would contribute to more symptoms of stress (Hypothesis 2).

Method

Participants and Procedure

Participants were 51 Belgian adolescents (49% female, *Mage* = 15.88, SD = 2.88, range = 12-19) who were all enrolled in secondary school education and following a general academic track. Two secondary school principals were contacted and asked if their school was willing to participate in the study. The principals then placed an advertisement for the study on their school's electronic learning platform and also asked interested teachers to notify the students in their class about the study and provided the students with an information sheet for their parents. Parents of adolescents who were interested in participating in the study contacted the researchers by e-mail. The researchers then contacted all of the adolescents who expressed interest and arranged to visit the school to explain the details and requirements of the study to small groups of students. During this school visit all adolescents were given an informed consent form, a diary and an actigraph watch and were made aware of the voluntary and confidential nature of the study. This informed consent form was taken home and signed by both the adolescents themselves and their parents before being returned to the researchers. The students were instructed to wear the actigraph watch for the whole duration of the study (i.e., for the full 7 days), and to fill the diary in twice a day, once in the morning directly after waking up and once in the evening directly before going to sleep. All students filled in the diary from a Monday morning to a Sunday evening. Adolescents who requested daily reminders to complete the questionnaires were sent text messages twice a day. The researchers visited the school a second time after the study period to collect the diaries and watches from the adolescents. All adolescents who successfully filled in the diary and wore the actigraph watch for the full 7 days received a cinema ticket for their participation. This study was approved by the host University's Ethical Review Board.

Daily Measures

Evening Measures

Daily Need Experiences. The daily satisfaction and frustration of adolescents' needs for autonomy, competence, and relatedness was assessed using a shortened version of the Basic Psychological Need Satisfaction and Need Frustration Scale (BPNSNFS; Chen et al., 2015), which is a cross-culturally validated extension of the BMPN scale used in Study 1. We chose to administer this shortened version, rather than the full 24 item scale, to limit participant burden. The shortened version proved valid in a previous study among elementary school children (Van der Kaap-Deeder et al., 2017) and consists of 12 items, 4 items per need, 2 of which tap into need satisfaction and 2 of which tap into need frustration. All participants rated on a scale of 1 (*not at all true*) to 5 (*very true*) as to whether they felt their needs for autonomy (e.g., "Today I felt that my decisions reflected what I really wanted" or "Today I felt forced to do things that I didn't choose to do"), competence (e.g., "Today I felt confident that I could do things well " or "Today I felt disappointed in my achievements") and relatedness (e.g., "Today I felt connected with the people who care about me and who I care about" or "Today I felt excluded from the group that I want to belong to") were satisfied or frustrated during the past day. Six separate need scores were created by averaging the items assessing the satisfaction of the needs for autonomy, competence and relatedness, as well as the items assessing the frustration of these needs. In addition, two need composite scores were created by computing the average of the three separate need satisfaction scores and by computing the average of the three separate need frustration scores. The composite scores of need satisfaction (average α = .82; range across days = .78 - .88) and need frustration (average α = .82; range across days = .78 - .85) had good reliability. Satisfaction of the needs for autonomy, competence, and relatedness had average reliabilities of .61 (range across days = .50-.76), .71 (range across days = .61-.80) and .75 (range across days = .56-.93), respectively, whereas their frustration had reliabilities of .76 (range across days = .71-.80), .77 (range across days = .65 - .82) and .71 (range across days = .65 – 76), respectively.

Daily Stress. Symptoms of stress were assessed using two items selected from the stress subscale of the short-form version of the Depression Anxiety and Stress Scale (DASS; Lovibond & Lovibond, 2004). The 2 items assessed the prevalence of two symptoms of stress during the past day (i.e., "Today I was very agitated" and "Today I noticed that I was very restless"). Participants rated both items on scale from 1 (*Completely disagree*) to 5 (*Completely agree*). The symptoms of stress had good reliability (average α = .89; range across days = .85 - .92).

Daily fatigue. Similar to Study 1, daily fatigue was assessed using the 7 item lassitude subscale from the Inventory of Depression and Anxiety Symptoms (IDAS; Watson et al., 2007), which was adapted so that it tapped into experienced fatigue during the past day (e.g. "Today I felt exhausted"). All items were rated on a 5-point Likert scale ranging from 1 (*not at all*) to 5 (*very much so*). The scale had an average reliability of .79; range across days = .76 - .84.

Morning Measures

Daily sleep Quality. Also similar to Study 1, daily sleep quality was assessed using a VAS form the Pittsburgh Sleep Diary (Monk et al., 1994) which assessed the previous night's sleep quality (i.e., "How was your sleep quality last night?") on a scale from 0 (*extremely poor* or *not at all*) to 100 (*extremely good* or *very much so*).

Daily objective Sleep Quantity. To obtain an objective estimation of daily sleep quantity, participants were instructed to wear a MotionWatch 8 actigraph watch (Wave Medical B.V.; The Netherlands) on their non-dominant arm for the duration of the study (i.e., for the full 7 days). The MotionWatch 8 is an unobtrusive, light-weight device worn on the wrist. The device includes a digital accelerometer which measures movement, thereby allowing for the differentiation between probable wake and sleep states for each 30-second period of recording. Participants were instructed to press the event marker button on the watch when they went to bed and when they got up in the morning, which inserted a marker in the actigraph recording. Daily sleep quantity was extracted from the actigraph data using the CamNtech MotionWare software (Version1.1.25) validated algorithm.

Plan of Analysis

Given that this data also involved repeated measurements (i.e., Level 1), nested within 51 adolescents (i.e., Level 2), we performed multilevel analysis using Mplus 7 to test our proposed integrated models. There were 9% missing values in the data. Little's MCAR was non-significant (normed χ^2 of 1.15), indicating that the data were likely to be missing at random. As a result full information maximum likelihood (FIML) was used to handle missing data in the structural equation models (SEM) (Little & Rubin, 1987).

Two 2-level SEM models were tested. In the first model we examined the intervening role of daily stress in the association between daily need experiences and daily fatigue and sleep (i.e., Hypothesis 1) and in the second model we examined the intervening role of daily need experiences in the relation between daily sleep and daily stress (i.e., Hypothesis 2). After inspecting the relation between background characteristics and the study variables the significant relation between age and objective sleep quantity was controlled for in the integrated models (see preliminary analysis). In each model all predictor variables were centered around each person's mean (i.e., group mean centered). Model fit was evaluated using the Comparative Fit Index (CFI); the Root Squared Error of Approximation (RMSEA) and the Standardized Root Means Square Residual (SRMR). An acceptable fit was indicated by CFI values of .90 or above, and RMSEA and SRMR values of around .08 or below (Hu & Bentler, 1999; Kline, 2005).

Results

Preliminary Analyses

Within-person correlations. The means, standard deviations and within-person (i.e., day-to-day) correlations between all of the daily measures are shown in Table 4. The composite score of daily need satisfaction was negatively related to daily stress and daily fatigue and was positively related to daily sleep quality but was unrelated to daily objective sleep quantity. The composite score of daily need frustration displayed similar associations with the study variables but in the opposite direction. However, different to daily need satisfaction, daily need frustration was also negatively related to daily objective sleep quantity. The three individual need satisfactions and need frustrations were fairly highly correlated and displayed a similar pattern of relations with the study variables. Lastly, daily stress was positively related to daily fatigue and negatively related to daily subjective sleep quality and objective sleep quantity.

Background variables. To examine the relation between background characteristics and the study variables a MANCOVA was performed with gender as a fixed factor, age as a covariate and all study variables as dependent variables. For these analyses all daily measures were aggregated across the 8 days. Gender (F[6, 43] = 1.77, *ns*) was unrelated to the study variables whereas age yielded a significant multivariate effect (F[6, 43] = 2.86, $p < .05$, $\eta^2 = .29$). Subsequent univariate analyses indicated that age was negatively related to daily objective sleep quantity (F[1, 48] = 16.14, $p < .01$, $\eta^2 = .25$). This significant relation between age and objective sleep quantity was controlled for in all primary analyses.

Intra-class correlations (ICC'S). The ICC values of all study variables are displayed in Table 4. Similar to results from Study 1, with regard to fatigue and the self-reported and objective sleep outcomes the ICC values indicated that a significant proportion of the variance in these variables could be attributed to the within-person level, with objective sleep quantity displaying the

Table 4

Means, Standard Deviations, Intra-Class Correlations and Within-Person Correlations between Study Variables - Study 2

	1	2	3	4	5	6	7	8	9	10	11	12
1. Need satisfaction	-											
2. Autonomy satisfaction	.85***	-										
3. Competence satisfaction	.81***	.53***	-									
4. Relatedness satisfaction	.79***	.48***	.49***	-								
5. Need frustration	-.64***	-.46***	-.54***	-.58***	-							
6. Autonomy frustration	-.48***	-.41***	-.33***	-.43***	.79***	-						
7. Competence frustration	-.57***	-.39***	-.60***	-.43***	.86***	.48***	-					
8. Relatedness frustration	-.51***	-.32***	-.37***	-.58***	.78***	.40***	.58***	-				
9. Fatigue	-.31***	-.23***	-.28***	-.25***	.48***	.45***	.42***	.28***	-			
10. Stress	-.25***	-.14**	-.28***	-.20***	.54***	.34***	.53***	.44***	.36***	-		
11. Subjective sleep quality	.16**	.06	.14**	.19***	-.28***	-.20***	-.21***	-.27***	-.17***	-.24***	-	
12. Objective sleep quantity	.05	.07	.01	.03	-.17***	-.13**	-.19***	-.08	-.07	-.21***	-.21***	-
Mean	3.48	3.19	3.41	3.84	2.09	2.39	2.32	1.58	2.40	2.19	71.99	415.77
SD	.73	1.00	.85	.85	.78	1.01	1.03	.83	.85	1.19	19.26	60.24
ICC	.45	.39	.39	.35	.57	.48	.48	.43	.32	.46	.50	.26

Note. *p<.05, **p < .01, p***<.001

most amount of variance within-individuals (i.e., approx. 74%) and subjective sleep quality displaying the least amount of variance within-individuals (i.e., approx. 50%). Also similar to findings form Study 1, ICC values indicated that approximately 55% and 43% of the variation in need satisfaction and need frustration, respectively, was situated within-individuals.

Primary Analyses

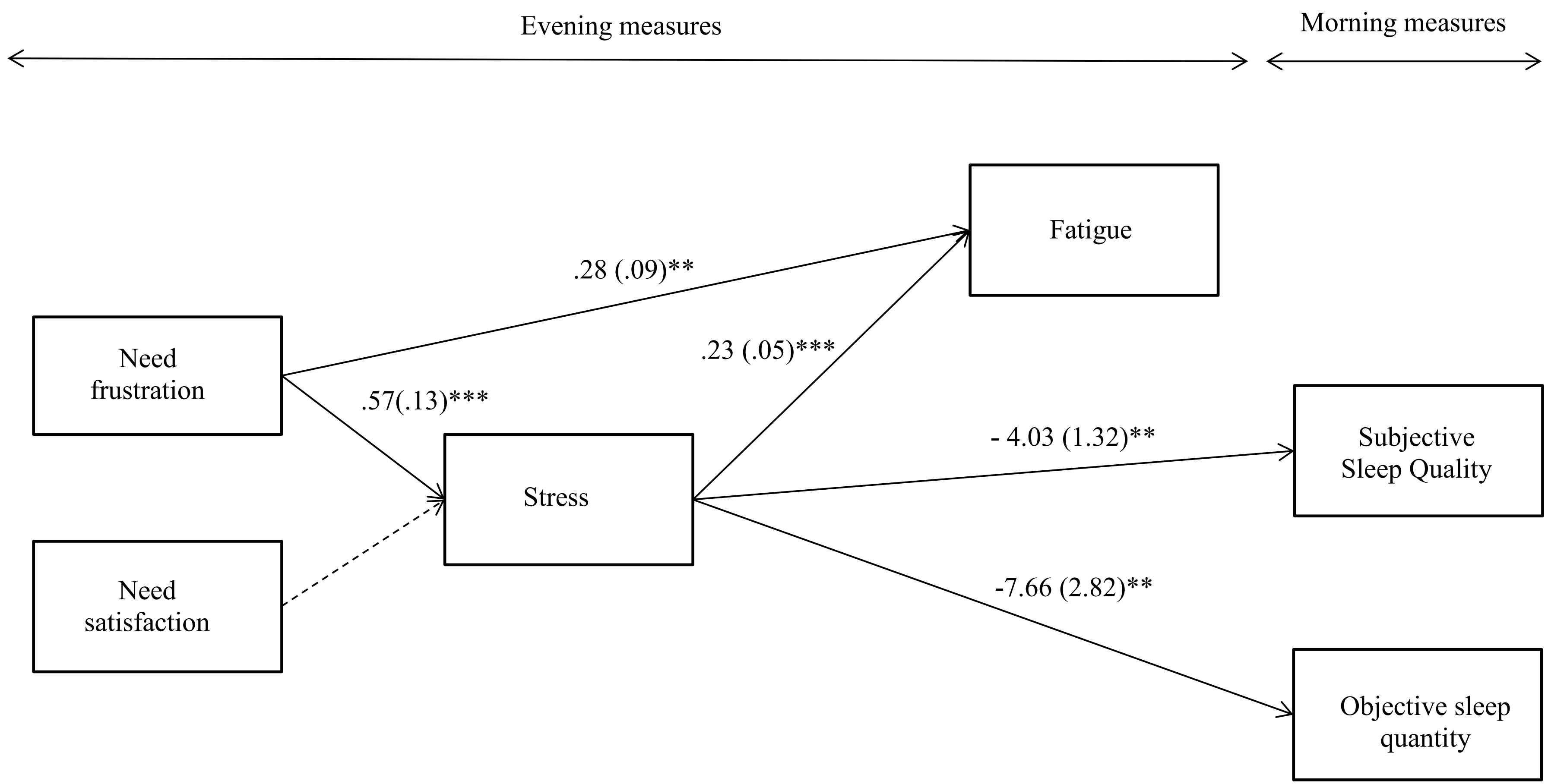
Hypothesis 1: Examining the intervening role of daily stress in the relation between daily need experiences and daily fatigue and sleep. To examine whether daily stress would play an explanatory role in the day-to-day association between need experiences and fatigue and sleep we specified a two-level SEM model. In this model, paths were added at the within-person level (i.e., daily level) from need satisfaction and need frustration to stress and from stress to the outcomes (i.e., fatigue, subjective sleep quality and objective sleep quantity), which were allowed to correlate. Results of this model, $X^2(6) = 12.05$, $p > .05$, CFI = .94, RMSEA = .05, SRMR = .04, indicated that daily need frustration was positively related to same-day stress (b = 0.57, $p < .001$), whereas daily need satisfaction was unrelated to same-day stress (b = -0.07, *ns*). Daily stress, in turn, was positively related to daily fatigue (b = 0.26, $p < .001$) and negatively related to same night sleep quality (b = -4.02, $p < .01$) and objective sleep quantity (b = -7.98, $p < .01$).

Next, direct paths were gradually added in between the predictor variables and the outcomes and were retained if the addition of a path led to an improved model fit. Only daily need frustration yielded a direct positive relation with daily fatigue, which led to an improved model fit, $X^2(5) = 3.97$, $p > .05$, CFI = 1, RMSEA = 0, SRMR = .02. The results of this final integrative model are shown in Figure 1. The indirect association between daily need frustration and daily fatigue (b = .13, $p < .01$), daily subjective sleep quality (b = -2.29, $p < .01$) and daily objective sleep quantity (b = -4.36, $p < .01$) via daily stress was significant.

In a supplementary analysis we tested an additional model in which we controlled for previous day levels of stress and the three daily outcomes (i.e., fatigue, subjective sleep quality &

Figure 1.

Daily Need Satisfaction & Need Frustration predicting daily fatigue and quality and quantity of sleep via daily stress



Note. *p<.05, **p < .01, p***<.001
Coefficients shown are unstandardized coefficients.

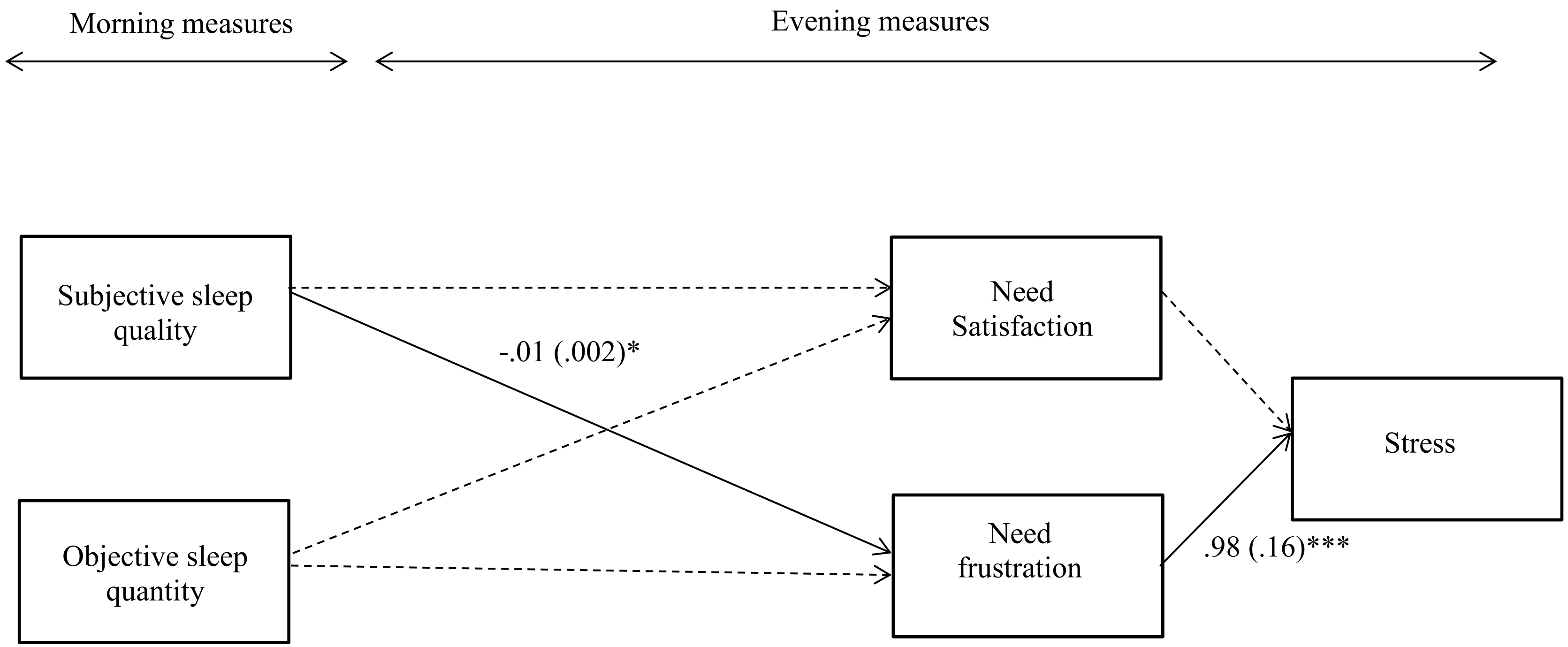
objective sleep quantity). Results of this more conservative model indicated that all within-day associations remained significant.

Hypothesis 2: Examining the intervening role of daily need experiences in the relation between previous night's sleep and next-day stress. In a next model, we examined whether daily need experiences would play an explanatory role in the relation between daily quality and quantity of sleep and daily stress. This was done by specifying another two-level SEM model and by adding paths at the within-person level (i.e., daily level) from subjective sleep quality and objective sleep quantity to need satisfaction and need frustration, and from need satisfaction and need frustration to stress. Results of this model, $X^2(2) = .57$, $p > .05$, CFI = 1, RMSEA = 0, SRMR = .01, displayed in Figure 2, indicated that daily sleep quality was uniquely negatively related to next-day need frustration, which in turn, was uniquely positively related to daily stress. The indirect association between daily sleep quality and next-day stress via daily need frustration ($b = -0.01$, $p < .05$), was significant. Next, direct paths were gradually added into this model between daily sleep quality and sleep quantity and daily stress, but were dropped because they were nonsignificant.

In a supplementary analysis, we tested another model in which we controlled for previous day levels of need experiences and stress. Results of this model revealed that after controlling for these previous day covariates the association between daily sleep quality and daily need frustration was no longer significant, whereas daily need frustration continued to yield a significant positive association with daily stress.

Figure 2.

Daily Sleep quality and sleep quantity predicting daily stress via daily need satisfaction and need frustration



Note. *p<.05, **p < .01, p***<.001
Coefficients shown are unstandardized coefficients.

Brief Discussion

The results from Study 2 indicate that daily need frustration, rather than low daily need satisfaction, related to more symptoms of stress, which in turn contributed to higher daily fatigue, poorer subjective sleep quality and shorter objective sleep quantity at night. This was the case even after controlling for the previous day levels of stress and the outcomes. Results further revealed that poorer subjective sleep quality, rather than shorter objective sleep quantity, was uniquely related to experiencing more need frustration throughout the day, which in turn contributed to higher symptoms of stress. However, the day-to-day association between sleep quality and need frustration was no longer significant after controlling for previous day levels of need frustration, indicating that poor sleep quality did not contribute to increases in need frustration across days. Overall, these findings indicate that daily need frustration not only relates to self-reported sleep but also relates to an objective indicator of sleep (i.e., objective sleep quantity) via daily stress. In addition, these results yielded evidence for the explanatory role of stress.

General Discussion

Although sleep disturbances in adolescence are highly prevalent (Gradisar et al., 2011) and have consistently been linked to poor adolescent functioning (Shochat, Cohen-Zen, Tzischinsky, 2014), few studies have identified psychological predictors of day-to-day variability in adolescent sleep. In line with previous diary studies (e.g., Fuligni & Hardway, 2006; Doane & Thurston, 2014; Galambos et al., 2009), the present findings demonstrated that adolescent quality and quantity of sleep fluctuates considerably from day-to-day. Importantly, the present research extended previous findings by examining whether the satisfaction and frustration of the basic psychological needs for autonomy, competence, and relatedness would contribute to this day-to-day variability in adolescent quality and quantity of sleep, as well as whether day-to-day variability in quality and quantity of sleep would contribute to adolescents' daily need experiences. Furthermore, the role of stress in these reciprocal day-to-day associations was also examined. A number of important findings emerged.

The Role of Daily Need Experiences in Predicting Daily Sleep

First, results from both studies revealed that daily need frustration in particular, contributed to poorer daily sleep quality. Specifically, results from Study 1 revealed that adolescents who experienced more need frustration during the day were more likely to report poorer sleep quality the following morning. Similar dynamics were found in Study 2 with daily need frustration relating to poorer daily sleep quality through (i.e., accounted for by) daily symptoms of stress, suggesting that stress plays an important explanatory role in these day-to-day associations. Notably, in both studies these associations remained significant even after controlling for the stability in sleep quality, suggesting that need frustration contributed to deterioration in sleep quality. These results are consistent with findings from previous studies carried out among college students (Campbell, Vansteenkiste, Beyers, & Soenens, 2017) and clinical (Campbell, Vansteenkiste, Delesie et al., 2017) samples, which similarly found within-person fluctuations in need frustration to relate to poorer sleep quality. Seemingly, the costs associated with experiences of daily need frustration interfere with the opportunity to recover through restful sleep at night.

In both studies daily need experiences also related to day-to-day variation in sleep quantity, with experiences of need frustration similarly playing a more prominent role. Results from Study 1 revealed that for every unit increase in experienced daily need frustration, adolescents reported, on average, half an hour less daily sleep. Study 2 replicated and extended these findings by demonstrating that daily need frustration also related to shorter objective sleep quantity through (i.e., accounted for by) higher daily stress, thereby providing further evidence for the critical explanatory role of stress in the daily need/sleep relation. However, the indirect relation between daily need frustration and shorter objective sleep quantity in Study 2 was less pronounced (8 minutes less daily sleep on average for every unit increase in stress). In both studies the association between daily need frustration and self-reported and objectively assessed sleep quantity remained significant after controlling for the previous day's amount of sleep, indicating that need frustration contributed to a reduction in sleep quantity. These findings are consistent with previous findings among college students which similarly found within-person increases in need frustration to relate to reductions in sleep quantity (Campbell, Vansteenkiste, Beyers, & Soenens, 2017). Overall, the present findings extend previous research among adolescents which found need frustration to confer risk for problem behaviors (Costa et al., 2016; Mabbe et al., 2016) by demonstrating that daily experiences of need frustration are also likely to leave adolescents vulnerable for shorter and poorer quality sleep at night.

The role of psychological needs was not limited to the prediction of quality and quantity of sleep but also held for daily fatigue. In both studies adolescents reported greater feelings of fatigue on days that their psychological needs were frustrated. Results from Study 2 revealed that this day-to-day association between need frustration and fatigue was only partially accounted for by higher symptoms of stress. These findings are consistent with a previous cross-sectional study of working adults which found low need satisfaction to relate to higher exhaustion (Van den Broeck, Vansteenkiste, Witte, Lens, 2008). Similar findings have also been reported in a diary study among working adults which found low need satisfaction to relate to a poorer recovery status at the end of a working day (Hooff & Geurts, 2014). However, these previous studies did not examine the differential role of both need satisfaction- and frustration in the prediction of fatigue. The present findings provide evidence that it is especially experiences of psychological need frustration which erode available energy leaving adolescents drained at the end of the day.

In line with recent theorizing (Vansteenkiste & Ryan 2013), the present findings underscore the critical maladaptive role of experiences of need frustration as it appeared that the active frustration of psychological needs, rather than low need satisfaction, contributed to higher symptoms of stress which in turn eroded adolescents energy levels and obstructed quality and quantity of sleep at night. These findings add to a growing body of empirical research (e.g., Bartholomew et al., 2011; Cordeiro et al., 2016; Van der Kaap-Deeder et al., 2016), which indicates that psychological need satisfaction- and frustration are distinct constructs with differential outcomes, with need frustration being especially predictive of ill-being, over and above a lack of need satisfaction.

The Role of Daily Sleep in Predicting Daily Need Experiences

Given the likely reciprocal relation between daily need experiences and sleep, in both studies we also examined the role of daily quality and quantity of sleep in predicting daily need experiences. In Study 1, results revealed that shorter self-reported daily sleep quantity related to lower need satisfaction and more need frustration throughout the day, whereas poorer sleep quality related to more daily need frustration. These associations remained significant after controlling for the previous days need experiences, suggesting that poorer quantity of sleep related to decreases in need satisfaction and increases in need frustration, whereas poorer quality sleep related to increases in need frustration. However, results from Study 2 only partially replicated these findings. Specifically, in Study 2 poorer self-reported sleep quality related to more daily need frustration which in turn related to more daily stress, whereas objective sleep quantity was unrelated to daily need experiences and daily stress. Furthermore, the relation between daily sleep quality and daily need frustration in Study 2 became nonsignificant after controlling for the previous day's level of need frustration and stress.

Overall, these results suggest that daily need frustration may be a more robust predictor of change in sleep than vice versa for two reasons. First, because need frustration systematically predicted change in quality and quantity of sleep across both studies and second, because the role of daily sleep in predicting need experiences was more variable, with daily sleep quantity only relating to need experiences in Study 1, and the association between sleep quality and need frustration not holding after controlling for previous day covariates in Study 2. However, these findings should be interpreted with caution as future experimental research is needed to draw firm conclusions about the direction of effects.

Limitations and Suggestions for Future Research

The present research has several limitations. First, the samples used in both studies were fairly homogenous which limits the generalizability of the findings. Future research is needed to replicate these findings among adolescents from more diverse socio-economic and cultural backgrounds. Furthermore, it would also be interesting to examine whether these findings extend to adolescents with a clinically diagnosed sleep disorder. Second, unfortunately actigraphy does not provide an objective indication of the quality of individuals' sleep. The use of self-reports to assess sleep quality in both studies may have inflated the observed association between daily need frustration and daily sleep quality through shared method variance. Future research could try to overcome this problem by using alternative objective measures of sleep such as polysomnography (Scholle et al., 2011) and determining how data derived from polysomnography can best be used to provide an objective indication of sleep quality. Furthermore, although these results suggest that psychological need frustration may be more a robust predictor of daily quality and quantity of sleep than vice versa; future experimental research is needed to shed more light on these causal pathways. For example, future experimental research could try to induce feelings of need satisfaction or need frustration among adolescents (e.g., Weinstein, Khabbaz, & Legate, 2016) and examine whether this impacts on their quality and quantity of sleep at night. Alternatively, experimental research could also induce sleep debt (e.g., Cote et al., 2009) within participants in order to more closely examine the impact of poor sleep on daily need experiences. Finally, future research should seek to identify moderators of the day-to-day association between psychological need experiences, stress and adolescent sleep. For example, future studies could examine the moderating role of adolescents dispositional mindfulness (Brown & Ryan, 2003) or self-critical perfectionism (Blatt, 2004), as both have previously been shown to influence stress reactivity (e.g., Weinstein, Brown, & Ryan, 2009; Bekes, et al., 2015).

Conclusion

In sum, the present research underscores the dynamic reciprocal interplay between adolescents' need experiences and sleeping pattern. Results revealed that on days that adolescents feel pressured and ineffective in their activities and disconnected from important others, they are more likely to experience symptoms of stress, which in turn are likely to erode their energy levels and interfere with the quality and quantity of their sleep at night. Results further suggest that after a night of poor quality sleep, adolescents are more likely to feel pressured and incapable of meeting their daily demands, which in turn may give rise to symptoms of stress, although this alternative pathway appeared to be less robust. These results imply that adolescents should be helped to both recognize and minimize sources of need frustration within their daily life to avoid the associated maladaptive pattern of stress and poor sleep at night.

References

Bartholomew, K. J., Ntoumanis, N., Ryan, R. M., & Thøgersen-Ntoumani, C. (2011). Psychological need thwarting in the sport context: Assessing the darker side of athletic experience. *Journal of Sport & Exercise Psychology, 33*, 75-102.

Becker, S. P., Langberg, J. M., & Byars, K.C. (2015). Advancing a biospychosocial and contextual model of sleep in adolescence: A review and introduction to the special issue. *Journal of Youth and Adolescence, 44*, 239-270.

Bekes, V., Dunkley, D.M., Taylor, G., Zuroff, D.C., Lewkowski, M., Foley, J. E., Myhr, G., & Westreich, R. (2015). Chronic stress and attenuated improvement in depression over 1 year: The moderating role of perfectionism. *Behavior Therapy, 46,* 478-492.

Blatt, S. J. (2004). *Experiences of Depression: Theoretical, Clinical and Research Perspectives*. Washinton, DC: American Psychological Association.

Bolger, N., Davis, A., & Rafaeli, E. (2003). Diary methods: Capturing life as it is lived. *Annual Review of Psychology, 54,* 579 – 616.

Boone, L., Vansteenkiste, M., Soenens, B., van der Kaap-Deeder, J., & Verstuyf, J. (2014). Self-critical perfectionism and binge eating symptoms: A longitudinal test of the intervening role of psychological need frustration. *Journal of Counseling Psychology, 61,* 363-373.

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology, 84*, 822–848. doi: 10.1037/0022-3514.84.4.822

Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index – a new instrument for psychiatric practice and research. *Psychiatry Research, 28*, 193–213. doi: 10.1016/0165-1781(89)90047-4.

Campbell, R., Tobback, E., Delesie, L., Vogelaers, D., Mariman, A., & Vansteenkiste, M. (2017). Basic psychological need experiences, fatigue, and sleep in individuals with unexplained chronic fatigue. *Stress & Health*.

Campbell, R., Vansteenkiste, M., Beyers, W., Soenens, B. (2017). University students' sleep during an exam period: The role of basic psychological needs and stress. *Manuscript submitted for publication.*

Campbell, R., Vansteenkiste, M., Delesie, L.M., Mariman, A. N., Soenens, B., Tobback, E., Van der Kaap-Deeder, J., & Vogelaers, D. P. (2015). Examining the role of psychological need satisfaction in sleep: A Self-Determination Theory perspective. *Personality and Individual Differences, 77,* 199-204.

Campbell, R., Vansteenkiste, M., Delesie, L. M., Soenens, B., Tobback, E., Vogelaers, D., & Mariman, A. (2016). The role of psychological need satisfaction, sleep, and mindfulness in the health related quality of life of people living with HIV. *Journal of Health Psychology.*

Campbell, R., Vansteenkiste, M., Delesie, L., Tobback, E., Mariman, A., & Vogelaers, D. (2017). Day-to-day fluctuations in subjective energy and sleep in chronic fatigue syndrome: The role of psychological need experiences. *Manuscript submitted for publication.*

Chen, B., Vansteenkiste, M., Beyers, W., Boone, L., Deci, E. L., Duriez, B. Lens, W., Matos, L., Mouratidis, A., Ryan, R. M., Sheldon, K. M., Soenens, B., Van Petegem, S., & Van der Kaap-Deeder, J., Verstuyf, J (2015). Basic psychological need satisfaction, need frustration, and need strength across four cultures. *Motivation and Emotion, 39,* 216-236.

Cordeiro, P., Paixao, P., Lens, W., Lacante, M., & Luyckx, K (2016). The portuguese validation of the basic psychological need satisfaction and frustration scale: Concurrent and longitudinal relations to well-being and ill-being. *Psychologica Belgica, 56(3),* 193-209.

Costa, S., Cuzzocrea, F., Gugliandolo, M. C., & Larcan, R. (2016). Associations between parental psychological control and autonomy support, and psychological outcomes in adolescents: The mediating role of need satisfaction and need frustration. *Child Indicators Research, 9*(4), 1059-1076.

Cote, K. A., Milner, C. E., Smith, B. A., Aubin, A. J., Greason, T. A., Cuthbert, B. P., Wiebe, S., & Duffus, S. E. G. (2009). CNS arousal and neurobehavioral performance in a short-term sleep restriction paradigm. *Journal of Sleep Research*, *18*, 3, 291 – 303. doi: 10.1111/j.1365-2869.2008.00733.x

Dahl, R. E., & Lewin, D. S. (2002). Pathways to adolescent health sleep regulation and behavior. *Journal of Adolescent Health, 31*, 175–184.

Deci, E. L. & Ryan, R. M. (2000). The ‘what’ and ‘why’ of goal pursuits: Human needs and the self determination of behavior. *Psychological Inquiry*, *11*, 227-268.

Doane, L. D., & Thurston, E. C. (2014). Associations among sleep, daily experiences, and loneliness in adolescence: Evidence of moderating and bidirectional pathways. *Journal of Adolescence, 37*, 145-154.

Emery, A. A., Toste, J. R., & Heath, N. L. (2015). The balance of intrinsic need satisfaction across contexts as a predictor of depressive symptoms in children and adolescents. *Motivation and Emotion*, *39*, 753-765.

Fuligni, A. J., & Hardway, C. (2006). Daily variation in adolescents’ sleep, activities, and psychological well-being. *Journal of Research on Adolescence, 16,* 353 – 377.

Galambos, N. L., Dalton, A. L., & Maggs, J. L. (2009). Losing sleep over it: Daily variation in sleep quantity and quality in Canadian students’ first semester of university. *Journal of Research on Adolescence, 19*, 741-761.

Galambos, N.L., Howard, A.L., & Maggs, J.L. (2010). Rise and fall of sleep quantity and quality with student experiences across the first year of university. *Journal of Research on Adolescence*, *21*, 342-349.

Gradisar, M., Gardner, G., & Dohnt, H. (2011). Recent worldwide sleep patterns and problems during adolescence: A review and meta-analysis of age, region, and sleep. *Sleep Medicine*, *12*, 110-118.

Granic, I., Hollenstein, T., Dishion, T. J., & Patterson, G. R. (2003). Longitudinal analysis of flexibility and reorganization in early adolescence: A dynamic systems study of family interactions. *Developmental Psychology*, *39*, 606-617.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6,* 1-55.

Krijgsman, C., Vansteenkiste, M., Van Tartwijk, J., Maes, J., Borghouts, L., Cardon, G., Mainhard, T., & Haerens, L. (2017). Performance grading and motivational functioning and fear in physical education: A self-determination theory perspective. *Learning and Individual Differences, 55,* 202-211.

Kline, R. B. (2005). Principles and practice of structural equation modeling. New York: Guilford Press.

Larson, R. W., Moneta, G., Richards, M. H., & Wilson, S. (2002). Continuity, stability, and change in daily emotional experience across adolescence. *Child Development, 73,* 1151-1165.

Little, R. J. A., & Rubin, D. B. (1987). *Statistical analysis with missing data*. New York: Wiley.

Lovibond, S. H., & Lovibond, P. F. (2004). Manual for the Depression Anxiety Stress Scales, second edition, Psychology Foundation, Sydney.

Mabbe, E., Soenens, B., Vansteenkiste, M., & Van Leeuwen, K. (2016). Do personality traits moderate relations between psychologically controlling parenting and problem behavior in adolescents? *Journal of Personality, 84,* 381-392.

Maciejewski, D. F., Lier, P. A., Branje, S. J., Meeus, W. H., & Koot, H. M. (2015). A 5-year longitudinal study on mood variability across adolescence using daily diaries. *Child Development, 86*, 1908-1921.

Miller, K., Danner, F., & Staten, R. (2008). Relationship of work hours with selected health behaviors and academic progress among a college student cohort. *Journal of American College Health, 56,* 675–679.

Monk, T. H., Reynolds, C. F., Kupfer, D. J., Buysse, D. J., Coble, P. A., Hayes, A. J., Machen, M. A., Petrie, S. R. & Ritenour, A. M. (1994). The Pittsburgh Sleep Diary. *Journal of Sleep Research, 3,* 111-120.

Pilcher, J. J., Ginter, D.R., & Sadowsky, B. (1997). Sleep quality versus sleep quantity: Relationships between sleep and measures of health, well-being and sleepiness in college students. *Journal of Psychosomatic Research, 42,* 355-378.

Pilcher, J. J., Schoeling, S.E., & Prosansky, C.M. (2000). Self-report sleep habits as predictors of subjective sleepiness. *Behavioral Medicine,* 25, 161-168.

Roberts, R. E., Roberts, C. R., & Xing, Y. (2011). Restricted sleep among adolescents: Prevalence, incidence, persistence, and associated factors. *Behavioral Sleep Medicine, 9*, 18–30.

Ryan, R. M., Bernstein, J. H., & Brown, K. W. (2010). Weekends, work, and well-being: Psychological need satisfactions and day of the week effects on mood, vitality, and physical symptoms. *Journal of Social and Clinical Psychology, 29,* 95-122.

Ryan, R. M., & Deci, E. L. (2008). From ego depletion to vitality: Theory and findings concerning the facilitation of energy available to the self. *Social and Personality Psychology Compass*, 2/2, 702-717.

Ryan, R. M., & Deci, E. L. (2017). *Self-Determination Theory: Basic psychological needs in motivation, development, and wellness*. New York: Guilford.

Scholle, S., Beyer, U., Bernhard, M., Eichholz, S., Erler, T., Graness, P., Goldmann-Schnalke, B., Heisch, K., Kirchhoff, F., Klementz, K., Koch, G., Kramer, A., Schmidtlein, C., Schneider, B., Walther, B., Wiater, A., Scholle, H.C. (2011). Normative values of polysomnographic parameters in childhood and adolescence: Quantitative sleep parameters. *Sleep Medicine, 6*, 542-549.

Shochat, T., Cohen-Zion, M., Tzischinsky, O. (2014). Functional consequences of inadequate sleep in adolescents: A systematic review. *Sleep Medicine Reviews, 18,* 75-87.

Sheldon, K. M.. Hilpert, J. C. (2012) The balanced measure of psychological needs (BMPN) scale: An alternative domain general measure of need satisfaction. *Motivation and Emotion, 4, 439-451.*

Smith, C. V. (2007). In pursuit of 'good' sex: Self-determination and sexual experience. Journal of Social and Personal Relationships, 24, 69–85.

Tremaine, R.B., Dorrian, J., Blunden, S. (2010). Subjective and objective sleep in children and adolescents: Measurement, age, and gender differences. *Sleep and Biological Rhythms, 8,* 229-238.

Van den Broeck, A., Vansteenkiste, M., De Witte, H., Lens, W. (2008). Explaining the relationships between job characteristics, burnout, and engagement: The role of basic psychological need satisfaction. *Work & Stress, 22,* 277-294.

Van der Kaap-Deeder, J., Vansteenkiste, M., Soenens, B., & Mabbe, E. (2016). Children's daily well-being: The role of mothers', teachers', and siblings' autonomy support and psychological control. *Developmental Psychology*.

Van Hooff, M. L. M., & Geurts, S. A. E. (2014). Need satisfaction during free evening hours: examining its role in daily recovery. *Stress and Health, 30,* 198 – 208.

Vansteenkiste, M., & Ryan, R. M. (2013). On psychological growth and vulnerability: Basic psychological need satisfaction and need frustration as a unifying principle. *Journal of Psychotherapy Integration, 23,* 263-280.

Véronneau, M. H., Koestner, R. F., & Abela, J. R. (2005). Intrinsic need satisfaction and well–being in children and adolescents: An application of the self–determination theory. *Journal of Social and Clinical Psychology, 24,* 280-292.

Verstuyf, J., Vansteenkiste, M., Soenens, B., Boone, L., & Mouratidis, A. (2013). Daily ups and downs in women's binge eating symptoms: The role of basic psychological needs, general self-control, and emotional eating. *Journal of Social and Clinical Psychology, 32,* 335-361.

Watson, D., O'Hara, M. W., Simms, L. J., Kotov, R., & Chmielewski, M. (2007). Development and validation of the Inventory of Depression and Anxiety Symptoms (IDAS). *Psychological Assessment, 19,* 253–268.

Weinstein, N., Brown, K. W., & Ryan, R.M. (2009). A multi-method examination of the effects of mindfulness on stress attribution, coping, and emotional well-being. *Journal of Research in Personality*, *43*, 374–385.

Weinstein, N., Khabbaz, F., & Legate, N. (2016). Enhancing need satisfaction to reduce psychological distress in Syrian refugees. *Journal of Consulting and Clinical Psychology*, *84*, 645-650.

Weinstein, N., & Ryan, R. M. (2011). A self-determination theory approach to understanding stress incursion and responses. *Stress and Health*, *27,* 4-17.

Zhou, H. Q., Shi, W. B., Wang, X. F., Yao, M., Cheng, G. Y., Chen, P. Y., & Li, D. G. (2012). An epidemiological study of sleep quality in adolescents in South China: A school-based study. *Child: Care, Health and Development, 38,* 581-587

Impact of Partial Sleep Deprivation on Psychological Functioning: Effects on Mindfulness and Basic Psychological Need Satisfaction[1]

Extending previous research on the psychological costs of sleep deprivation, the present study examined the impact of insufficient sleep on the capacity to be mindful as well as on the satisfaction of individuals' basic psychological needs, two psychological resources of mental health. The interrelationship between these two psychological resources and fatigue following sleep deprivation was also examined. Participants were 49 adults (77% female; *M*age = 32.81 years, *SD* = 13.09 years) who were randomly assigned to either an experimental (*N* = 23) or a control (*N* = 26) group. The study had a four day within-person design. In the experimental group, a baseline assessment day was followed by three days of partial sleep deprivation (i.e., 5 hours sleep per night), whereas participants in the control group slept as usual across the four day period. Participants rated their fatigue and psychological functioning each evening and wore an actigraph watch which monitored their sleep. Participants reported increased fatigue after one day of sleep deprivation, whereas it took three days of sleep deprivation before their mindfulness and need satisfaction deteriorated. Mediational analyses indicated that decreased need satisfaction after three days of sleep deprivation was completely accounted for (i.e., explained) by increased fatigue and subsequent decreases in mindfulness. These findings build on previous research by showing that mindfulness and need-based experiences not only precede but also follow from sleep at night.

[1] Campbell, R., Soenens, B., Weinstein, N., & Vansteenkiste, M. (2017). Impact of partial sleep deprivation on psychological functioning: Effects on mindfulness and basic psychological need satisfaction. *Manuscript submitted for publication.*

Introduction

Sleep deprivation is rampant in modern society. Although it is recommended that adults sleep seven hours or more per night to function optimally (Watson et al., 2015), recent polls and studies indicate that up to 40% of the general public sleep less than six hours a night on average (Ford, Cunningham, & Croft, 2015; Jones, 2013). Insufficient sleep can have a detrimental impact on physical functioning, with fatigue being one of the most immediate manifestations of sleep deprivation (e.g., Klumpers et al., 2015; Minkel et al., 2014). Apart from fatigue, lack of sleep also comes at a considerable psychological cost and has been shown to result in depressed mood (Kahn-Greene, Killgore, Kamimori, Balkin, & Killgore, 2007), elevated anxiety (Pires, Bezerra, Tulfik, & Andersen, 2016), and impaired cognitive functioning (e.g., Frenda & Fenn, 2016). The present study sought to further investigate the psychological effects of sleep deprivation on two important predictors of individuals' well-being. Specifically, we examined the effects of insufficient sleep on individuals' capacity to be mindful, as well as on the satisfaction of individuals' basic psychological needs for autonomy, competence, and relatedness (Ryan & Deci, 2017).

Mindfulness is conceptualized as an open awareness of present moment experiences (Brown & Ryan, 2003). There is rising interest in mindfulness in the health literature because an increasing number of studies indicate that being mindful has salutary effects on psychological (e.g., Chiesa, & Serretti, 2009; Vollestad, Nielsen, & Nielsen, 2012) and physical health (e.g., Davidson et al., 2003; Riebel, Greeson, Brainard, Rosenweig, 2001). More relevant to the present research, a number of correlational (e.g., Howell, Digdon, & Buro, 2010; Howell, Digdon, Buro, & Sheptycki, 2008) and mindfulness-based intervention studies (e.g., Kanen, Nazir, Sedky, & Pradhan, 2015) indicate that being mindful *leads to* better sleep quality and longer sleep duration. This is presumably because mindfulness allows for a more observant and accepting approach to sleep-interfering arousal processes which promotes better sleep at night (Lundh, 2005). However, although a lack of mindfulness might leave individuals vulnerable to poor sleep, the reverse is also plausible, namely that being sleep deprived may interfere with individuals' capacity to be mindful. Yet, to the best of our knowledge no studies have directly examined this alternative causal pathway.

Previous experimental research provides some indirect evidence which suggests that insufficient sleep may undermine our capacity to be mindful. For instance, experimental studies have found that sleep deprivation leads to a lack of focused attention (Harrison & Horne, 2000), with partial sleep deprivation (i.e., sleeping 5 hours a night) increasing individuals' distractibility during monotonous tasks (Anderson & Horne, 2006). Furthermore, a more recent experimental study found that total sleep deprivation (i.e., total sleep loss for 24 hours) resulted in increased mind wandering (i.e., having task-unrelated thoughts) during a subsequent visual task (Poh, Chong, & Chee, 2016). Given that mindfulness involves purposefully paying attention to events and experiences as they occur (Brown & Ryan, 2003), these findings imply that mindfulness is likely to be impaired by sleep deprivation.

A second important aspect of psychological functioning which may be impacted by sleep deprivation is the satisfaction of individuals' basic psychological needs. Self-Determination Theory (SDT; Ryan & Deci, 2017) identifies three basic psychological needs which are thought to be universal and essential for mental health. These are the need for autonomy – experiencing a sense of volition and choice in one's activities, the need for competence – feeling capable of achieving desired outcomes, and the need for relatedness – feeling connected to, and cared for, by important others. Whereas need satisfaction is important for well-being and optimal functioning, the active frustration (i.e., experiencing pressure, incompetence, loneliness) of these needs is said to elicit maladaptive functioning (Vansteenkiste & Ryan, 2013).

These three basic psychological needs are central to individuals' well-being, psychosocial adjustment, and physical health (Ryan & Deci, 2017). Studies have demonstrated their satisfaction to relate to psychological well-being, including life satisfaction, positive emotions, and subjective energy (Chen et al., 2015; Deci & Ryan, 2000; Reis, Sheldon, Gable, Roscoe & 2000), whereas their frustration has been shown to predict ill-being and to deplete energetic resources (e.g., Bartholomew, Ntoumanis, Ryan, & Thøgersen-Ntoumani 2011). Several studies have also found a relation between SDT's psychological needs and quality and quantity of sleep among healthy adults (Campbell et al., 2015) and clinical samples at risk for poor sleep (Campbell et al., 2016; Campbell et al., 2017). Interestingly, findings from a recent diary study among adolescents indicated that poorer self-reported quality and quantity of sleep related to more need frustration throughout the day (Campbell, Vansteenkiste, Soenens, Vandenkerckhove & Mouratidis, 2017). However, the correlational nature of these findings prevented conclusions about the direction of effects.

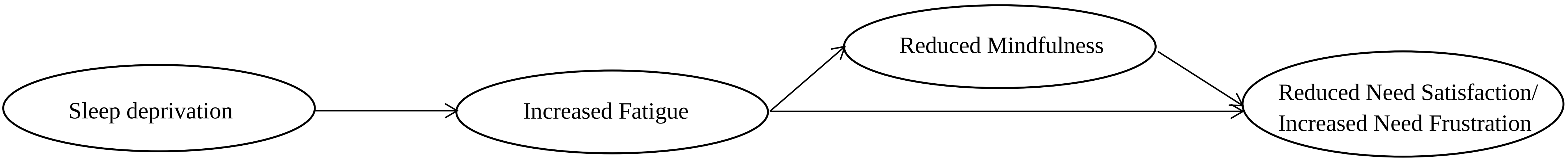
Indeed, given that sleep deprivation reduces subjective energy (e.g., Frenda & Fenn, 2016), and that energy is presumably required to remain present and attentive to daily experiences (i.e., mindful), insufficient sleep is likely to undermine psychological need satisfaction. Thus, reduced mindfulness resulting from depleted energy is likely to preclude individuals from selecting need-satisfying activities as well as prevent them from deriving a sense of need satisfaction from ongoing activities throughout the day. There is indirect evidence for the latter part of our reasoning, with studies indicating that mindfulness relates positively to need satisfaction and that, conversely, low mindfulness increases individuals' susceptibility for need frustrating experiences (e.g., Brown & Ryan, 2003). The present study, however, is the first to formally test the possibility that sleep deprivation *causally* impacts on daily need experiences through increases in fatigue which then in turn impairs present moment awareness (i.e., reduced mindfulness). Furthermore, given that energy is needed to proactively engage in and seek opportunities for need satisfaction, we also considered the possibility that reduced energy following sleep deprivation (i.e., fatigue) may directly undermine psychological need satisfaction. Thus, we also explored whether fatigue would directly result in lower need satisfaction/more need frustration (i.e., without being accounted for by impaired mindfulness). The hypothesized conceptual model is depicted in Figure 1.

Present Research

The main objective of the present study was to examine the impact of partial sleep deprivation (i.e., sleeping less than 5 hours a night) on subjective fatigue, mindfulness and psychological need-based experiences. We chose to examine the impact of partial sleep deprivation (i.e., less than 5 hours sleep per night) rather than total sleep deprivation (i.e., total sleep loss for 24 hours) because it is likely to be more representative of what sleep deprivation constitutes among the general public and therefore more ecologically valid. Furthermore, this sleep debt induction is

Figure 1

The hypothesized model



similar to manipulations used in other research which examined the physical and psychological consequences of sleep deprivation (e.g., Dinges et al., 1997).

We hypothesized that sleep deprivation would result in increased fatigue, impaired mindfulness and reduced need-based experiences (as indexed by reduced need satisfaction and increased need frustration; i.e., Hypothesis 1). Apart from examining the main effect of sleep deprivation, our second objective was to explore in greater detail how these hypothesized changes in fatigue and psychological functioning (i.e., mindfulness and need experiences) relate to one another. Specifically, we examined whether increased fatigue stemming from sleep deprivation would lead to poorer psychological functioning. We hypothesized that increases in fatigue following sleep deprivation would relate to decreased need satisfaction and increased need frustration both directly and indirectly via reduced mindfulness (i.e., Hypothesis 2).

Method

Participants

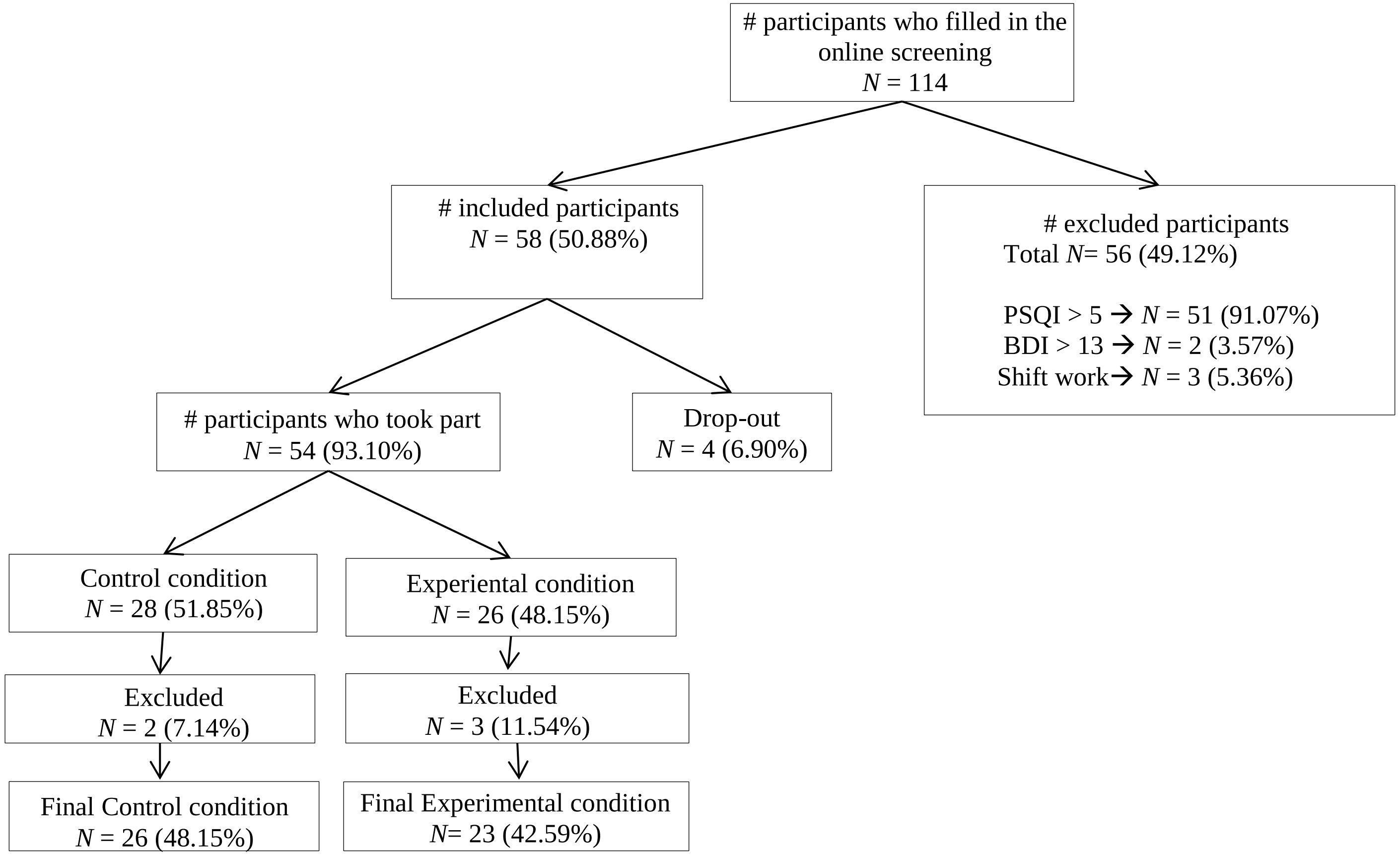
All participants were recruited via flyers and online advertisements which were placed on social media. The final sample consisted of 49 Belgian adults (See Figure 2 for a flow chart displaying the selection process for these participants, and a full description of this process below). The mean age of the sample was 32.81 years (SD = 13.09, range = 21–69 years). Sixty-seven percent of the final sample was female; 53% were employed and the remaining 47% were unemployed or students.

Procedure

The study consisted of two parts. In the first part participants were screened using an online questionnaire and in the second part the experimental study was conducted. Prior to filling in the online questionnaire (i.e., part 1) all participants were made aware of the voluntary nature of the study and their anonymity was guaranteed. Participants were informed that they may be asked to deprive their sleep in the second part of the study. Online informed consent was obtained from all participants. Participants who only completed the first part of the study received one cinema ticket for their participation and participants who completed both parts received two cinema tickets. The

Figure 2

Flow chart of participation



study was carried out between February 2016 and May 2016 and was approved by Ghent University's Ethical Review Board.

Part 1 (screening)

An online questionnaire was used to screen participants for the following inclusion criteria: participants were required to be older than 18 years of age, could not have children under the age of three, use sleep medication, have severe sleep disturbances or depressive symptoms, given the likely impact of these factors on sleep. Of the 114 individuals who filled in the online screening, 58 (50.88%) met the inclusion criteria and were invited to participate in part 2. Of the 58 participants who were invited to participate, 4 (6.90%) declined because they were not willing to deprive their sleep. The remaining 54 participants were randomly allocated to the experimental group (*N* = 26) and the control group (*N* = 28; Figure 2).

Part 2 (experimental study)

The study involved a four-day within-person design. In the experimental group participants were instructed to sleep as usual on the first day of the study (i.e., Day 1 see Table 1 for an overview of the experimental design) and on the following three consecutive days they were instructed to restrict their sleep to 5 hours per night, whereas participants in the control group were simply instructed to sleep as usual for the four days. Participants in the experimental group were free to choose when they wanted to sleep at night (e.g., between 00:00 and 5:00 or between 02:00 and 07:00). All participants took part from a Sunday evening to a Thursday morning to avoid weekend effects (Ryan, Bernstein, & Brown, 2010). Participants were allowed to choose which month they wanted to participate in the study (either February, March, April or May) and were informed whether they would be required to deprive their sleep or not on the first day of the study (i.e., on the Sunday morning). During a first home visit trained research assistants provided participants with a diary and an actigraph watch. Participants in both groups filled in the diary every evening and rated items assessing their fatigue and psychological functioning (i.e., mindfulness and psychological need experiences). All participants also wore the actigraph watch for the full duration

Table 1

The Experimental Design

	Screening	Baseline assessment	Experimental phase		
		Day 1: Sunday	Day 2: Monday	Day 3: Tuesday	Day 4: Wednesday
Experimental Group		Morning assessment	Morning assessment	Morning assessment	Morning assessment
		Evening assessment	Evening assessment	Evening assessment	Evening assessment
		Slept as usual	1st sleep deprivation night	2nd sleep deprivation night	3rd sleep deprivation night

Note. The control group followed the same procedure but slept as usual on day 2, 3, & 4.

of the study which objectively monitored their sleep duration. During a second home visited the completed diaries and actigraph watches were collected by the research assistants.

After preliminary inspection of the data results from five participants were deemed invalid and were removed from the data set. These were data from three participants from the experimental group who failed to comply with the sleep restriction protocol and two participants from the control group who slept less than 5 hours a night throughout the duration of the study. This resulted in a final sample of 23 in the experimental group and 26 in the control group (total n = 49).

Measures

Screening Measures

Pittsburgh Sleep Quality Index (PSQI). The PSQI (Buysse et al., 1989) was used to screen participants for sleep disturbances. The PSQI consists of 19 items which generate scores on 7 components: subjective poor sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of hypnotics, and daytime dysfunction. These component scores are then summed to produce a global score between 0 and 21. A global PSQI score of > 5 distinguishes between poor and good sleepers (Buysse et al., 1989), with higher scores indicating worse sleep quality. All participants who initially scored above 5 were excluded from participating in the experimental phase of the study to ensure a healthy and homogenous sample. Of the 114 participants who completed the screening measure, 44.74% (n = 51) were excluded due to scoring above the cut-off of 5.

Beck Depression Inventory-II (BDI). The BDI-II (Beck, Steer, & Brown, 1996) screened participants for depressive symptoms. Participants were asked to rate the 21 depressive symptoms on a scale from 0 (*not present*) to 3 (*severe*) with respect to how they felt during the past week. Scores were summed to provide an overall score between 0-63. BDI scores from 0-13 suggest absent to minimal depressive symptoms, whereas scores from 14-63 represent mild to severe depressive symptoms. Two participants (1.74% of the sample) who scored above 13 were excluded from participating in the study.

Daily Measures

Fatigue. Fatigue was assessed using the lassitude subscale from the Inventory of Depression and Anxiety Symptoms (IDAS; Watson et al., 2007). This six-item scale was adapted to assess symptoms of fatigue experienced during the past day (e.g., "Today I felt sleepy and drowsy"). All items were rated on a 5-point Likert scale ranging from 1 (*not at all*) to 5 (*very much so*). The scale had an average reliability of .87; range across days = .84 - .89.

Mindfulness. State mindfulness was measured using a validated shortened version of the Mindfulness Attention Awareness Scale (MAAS; Brown & Ryan, 2003). This version consists of five items (i.e., "Today I said or did things on 'automatic pilot' without being conscious of what I did or said") which assessed the extent to which participants were mindful during the past day on a scale of 1 (*Completely disagree*) to 6 (*Completely agree*). The MAAS had an average reliability of .74, range across days = .68-.77.

Psychological Needs Experiences. Daily satisfaction and frustration of the basic psychological needs for autonomy, competence, and relatedness were assessed using the Basic Psychological Need Satisfaction and Need Frustration Scale (BPNSNFS; Chen et al., 2015). The scale consists of 24 items, eight items per need, four of which tap into need satisfaction and four of which tap into need frustration. All participants rated on a scale of 1 (*not at all true*) to 5 (*very true*) as to whether they felt their needs for autonomy (e.g., "Today I felt that my decisions reflected what I really wanted", "I felt forced to do many things that I didn't choose to do"), competence (e.g., "Today I felt capable of achieving my goals", "I had serious doubts about whether I could do things well") and relatedness (e.g., "Today I felt connected with the people who care about me and who I care about", " Today I felt excluded from the group that I want to belong to") were satisfied or frustrated during the past day. The validity of the diary format of the BPNSNFS has been proven (Van der Kaap-Deeder et al., 2017). Two composite scores were created by averaging the 12 items assessing need satisfaction (average α = .91; range across days = .90-.91) and the 12 items that assessed need frustration (average α = .87; range across days = .85-.89).

Objective Registration of Sleep Duration

To objectively register daily sleep duration all participants wore a MotionWatch 8 actigraph watch (Wave Medical B.V.; The Netherlands) for the full duration of the experimental study. The MotionWatch 8 is an unobtrusive, light-weight device which was worn by all participants on their non-dominant arm. The device includes a digital accelerometer which measures movement, thereby allowing for the differentiation between wake and sleep states for each 30-second period of recording. Daily sleep duration was extracted from the actigraph data using the CamNtech MotionWare software (Version1.1.25) validated algorithm.

Plan of Analysis

To examine whether the induced sleep deprivation had an effect on the study variables (i.e., Hypothesis 1), repeated measures ANOVAs were performed using SPSS. In these analyses we examined whether shifts in the assessed constructs from one measurement moment to another differed in the control- versus the experimental condition. Specifically, for each dependent variable (i.e., fatigue, mindfulness, need satisfaction, and need frustration) condition (i.e., control group versus experimental group) was included as a between-person factor and time was included as a within-person factor. Specifically, the following comparisons were made: (1) baseline assessment versus sleep deprivation day 1, (2) baseline assessment versus sleep deprivation day 2, (3) baseline assessment versus sleep deprivation day 3. We chose to examine effects of sleep deprivation in this stepwise fashion (rather than through one omnibus effect across the days) so as to gain insight into exactly when (i.e., on which day) the effects of the sleep deprivation manifested.

Having established effects of sleep deprivation on changes in each of the separate study variables, we then examined the integrated model depicted in Figure 1. To test this model, we estimated within-person changes in each of the study variables through latent change models (LCMs) in Mplus 7 (with Maximum Likelihood as estimator). LCMs are widely acknowledged as a more reliable method to estimate change compared to difference scores. Specifically, they estimate within-person change across two measurement moments (e.g., from the baseline assessment to sleep deprivation day 3) using latent variables for intercept (i.e., level) and slope (i.e., change over time) (Beyers & Goossens, 2008). Each latent change model consisted of a longitudinal measurement model defining the latent variables (i.e., fatigue, mindfulness, need satisfaction, and need frustration) at each time point by their respective indicators and a structural model which defined latent level and change factors for each latent variable and further specified how these levels and changes were interrelated (Hertzog, Dixon, Hultsch, & MacDonald, 2003). Further, co-variances among the residuals of the same indicators over time were specified (Sörbom, 1975). In the longitudinal measurement model, each latent variable was represented by two parcels. Parcels were created by combining stronger loading items with weaker loading items from each scale (Little, Cunningham, Shahar, & Widaman, 2002).

The latent factor scores for the level (i.e., intercept) and within-person changes in each variable were extracted and saved as separate variables. These saved variables were then used to test the proposed integrated models in Mplus7. Specifically, a structural model was tested in which we examined whether within-person decreases in fatigue resulting from sleep deprivation would lead to decreases in mindfulness, and whether decreases in mindfulness would then in turn lead to impaired need experiences (i.e., Hypothesis 2). Model fit was evaluated using the Comparative Fit Index (CFI); the Root Squared Error of Approximation (RMSEA) and the Standardized Root Means Square Residual (SRMR). An acceptable fit was indicated by CFI values of .90 or above, and RMSEA and SRMR values of around .08 or below (Hu & Bentler, 1999; Kline, 2005). Background characteristics (i.e., age and gender) were controlled for in all models.

Results

Preliminary Analysis

Background variables. The relation between participants' background characteristics (i.e., age and gender) and the study variables was examined using a MANCOVA with gender as a between-subjects variable, age as a covariate and all the study variables as dependent variables. Neither participants' age, $F(19, 24) = 1.69$, *ns*, or gender, $F(19, 24) = .12$, *ns*, yielded a significant multivariate main effect.

Manipulation check. To examine whether participants in the experimental group slept fewer hours relative to their baseline assessment and relative to the control group a series of repeated measures ANOVAs were performed with objectively assessed sleep duration as an outcome. As shown in Table 2, all Time X Condition interactions were significant, indicating that the experimental group and control group displayed different trajectories in sleep duration. Furthermore, as shown in Table 3 the mean scores indicated that participants in the experimental group slept less than the control group and averaged 4:38, 4:38, and 4:30 hours of sleep on sleep deprivation day 1, 2 and 3, respectively. These findings indicate that the experimental manipulation of sleep duration was successful.

Primary Analysis

Hypothesis 1: Main Effects of Sleep Deprivation. In Table 2, the condition effects, time effects and time X condition interactions are shown for each of the assessed study variables. Significant time X condition interactions indicate that the control group and experimental group displayed a different trajectory in the assessed outcomes from the baseline assessment to the sleep deprivation days. As this is most relevant to our research question, we will limit ourselves to discussing the findings of these interactions.

With regard to fatigue, all time X condition interactions were significant. This indicated that relative to the control group, participants in the sleep deprivation condition reported significantly more fatigue already after one day of sleep deprivation, with this effect becoming stronger across the following two additional days of sleep deprivation. In contrast, with regard to psychological functioning (i.e., mindfulness and need-based experiences) the time X condition interactions were only significant after three days of sleep deprivation. This indicated that it took three days of sleep deprivation before participants in the experimental group reported significantly reduced mindfulness and lower need satisfaction, relative to both the control group and their baseline assessment. Of note, none of the time X condition interactions were significant for need frustration, indicating that the experimental manipulation did not cause an increase in participants' experienced

Table 2

Repeated Measures Mixed Model ANOVA

Baseline vs Sleep deprivation	**Condition**						**Time**						**Condition x Time**					
	BL – SD1		**BL – SD2**		**BL – SD3**		**BL – SD1**		**BL – SD2**		**BL – SD3**		**BL – SD1**		**BL-SD2**		**BL – SD3**	
	F	**η^2**	***F***	**η^2**	***F***	**η^2**	***F***	**η^2**	***F***	**η^2**	***F***	**η^2**	***F***	**η^2**	***F***	**η^2**	***F***	**η^2**
Manipulation check																		
Objective sleep duration	35.31**	.43	29.76**	.39	41.30**	.47	70.50**	.60	88.26**	.65	101.82**	.68	55.93**	.54	40.99**	.47	75.75**	.62
Daily Measures																		
Fatigue	.04	.00	1.99	.05	5.26*	.10	4.53*	.10	20.79**	.31	21.38**	.32	9.60**	.18	40.19**	.46	41.88**	.47
Mindfulness	.15	.00	.30	.01	3.95*	.08	2.48	.05	1.01	.02	.45	.01	.28	.01	.61	.01	8.18**	.15
Need satisfaction	1.94	.04	2.94	.06	5.11*	.10	4.96*	.10	4.69*	.09	1.02	.02	.18	.00	.19	.00	4.39*	.09
Need frustration	2.28	.05	2.23	.05	5.01*	.10	1.22	.03	.09	.00	1.57	.03	.32	.01	.21	.00	.55	.01

Note. *p<.05, **p < .01

BL: baseline assessment, SD1: sleep deprivation day 1, SD2: sleep deprivation day 2, SD3: sleep deprivation day 3

Table 3

Means and Standard Deviations for all Study Variables from the Control Group and the Experimental Group

Variable (unit)	**Control group**	**Experimental group**
	Mean (SD)	**Mean (SD)**
Objective sleep quantity (min)		
Baseline	423.81 (52.07)	416.70 (58.29)
Sleep deprivation day 1	415.81 (65.54)	278.30 (18.04)
Sleep deprivation day 2	397.69 (56.29)	278.83 (29.05)
Sleep deprivation day 3	413.00 (54.62)	270.26 (19.63)
Fatigue (1-5)		
Baseline	1.99 (.85)	1.73 (.77)
Sleep deprivation day 1	1.89 (.95)	2.25 (.77)
Sleep deprivation day 2	1.77 (.74)	2.61 (.78)
Sleep deprivation day 3	1.72 (.66)	2.91 (.94)
Mindfulness (1-5)		
Baseline	4.06 (.75)	4.04 (.70)
Sleep deprivatieon day 1	3.96 (.73)	3.84 (.64)
Sleep deprivation day 2	4.04 (.74)	3.86 (.69)
Sleep deprivation day 3	4.30 (.63)	3.66 (.69)
Need Satisfaction (1-5)		
Baseline	4.16 (.58)	3.92 (.56)
Sleep deprivation day 1	4.04 (.57)	3.84 (.59)
Sleep deprivation day 2	4.06 (.59)	3.77 (.56)
Sleep deprivation day 3	4.21 (.52)	3.76 (.59)
Need Frustration (1-5)		
Baseline	1.53 (.51)	1.76 (.59)
Sleep deprivation day 1	1.50 (.54)	1.68 (.41)
Sleep deprivation day 2	1.54 (.58)	1.72 (.46)
Sleep deprivation day 3	1.38 (.41)	1.73 (.56)

need frustration. These findings are reflected in the mean scores for each variable across both conditions, which are shown in Table 3.

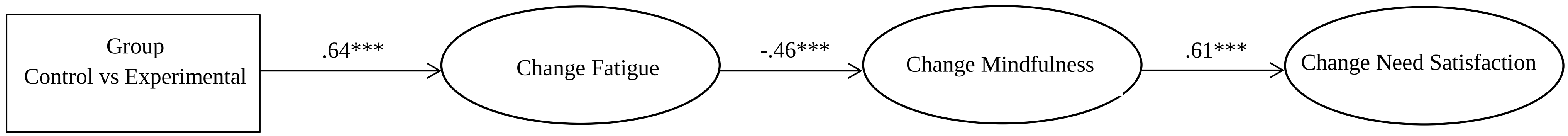
Hypothesis 2: Explanatory Chain of Mechanisms. A SEM model was tested to examine the hypothesized chain of mechanisms following sleep deprivation, that is, whether changes in fatigue would relate to changes in mindfulness which, in turn, would account (i.e., explain) for the relationship between sleep deprivation and reduced need satisfaction. Given that effects were only found on all variables after three days of sleep deprivation, we focused on changes from the baseline assessment to sleep deprivation on day 3 in these models. Also, because sleep deprivation did not affect need frustration, need frustration was no longer included in these models. Paths were modeled from the experimental contrast (i.e., control group versus experimental group) to change in fatigue, from change in fatigue to change in mindfulness, and from change in mindfulness to change in need satisfaction. Furthermore, the baseline levels of all variables were controlled for. Results of this model, shown in Figure 3, $X^2/df = .71$, CFI = .99, RMSEA = .04, SRMR = .08, indicated that three days of sleep deprivation contributed to an increase in fatigue, which in turn related to a decrease in mindfulness, which then in turn related to reduced need satisfaction. Next, direct paths were added from the experimental contrast to change in mindfulness and need satisfaction and from change in fatigue to change in need satisfaction but these paths were dropped because they were non-significant and adding them did not improve model fit. Finally, the indirect association between the experimental sleep deprivation and reduced need satisfaction via increased fatigue and reduced mindfulness was significant ($\beta = -.18$, $p < .01$; CI 95% [-.285; -.075]).

Supplementary Analysis

In a supplementary analysis, we examined an alternative sequence, namely we explored whether reduced psychological functioning due to sleep deprivation would also contribute to increased fatigue, in line with the nascent literature suggesting causal effects of psychological need satisfaction on subjective energy (e.g., Martela & Ryan, 2016). That is, we considered the possibility that reductions in mindfulness following sleep deprivation would undermine need-based experiences which then, in turn, would predict further increases in fatigue.

Figure 3

Experimental contrast predicting changes in need satisfaction via changes in fatigue and mindfulness



Note. *p<.05, **p < .01, p***<.001.
All changes shown are from the baseline assessment to sleep deprivation day 3.

Specifically, this model defined paths from the experimental manipulation to change in mindfulness, from change in mindfulness to change in need satisfaction, and lastly, form change in need satisfaction to change in fatigue (all changes represented changes from baseline to day 3). Results revealed that sleep deprivation contributed to reduced mindfulness (β = -.38, p < .001), which in turn related to reduced need satisfaction (β = .58, p < .001), however the relation between change in need satisfaction and change in fatigue was non-significant (β =.05, *ns*). Rather, results indicated that reduced mindfulness yielded a direct relation with increased fatigue (β = -.43, p < .001), which was not accounted for by reductions in need satisfaction. This non-significant path between change in need satisfaction and fatigue was dropped from the final model, X^2/df = 1.05, CFI = .99, RMSEA = .03, SRMR = .07. Notably, the effect of mindfulness on increased fatigue emerged above and beyond the effect of the experimental sleep deprivation on increased fatigue (β =.49, p < .001), indicating that reduced mindfulness only partially accounted for the association between sleep deprivation and fatigue. The indirect associations between the experimental sleep deprivation and reduced need satisfaction (β = -.22, p < .01; CI 95% [-.338; -.083]) and increased fatigue (β = .15, p < .001; CI 95% [.080; 237]) via reduced mindfulness were both significant. Overall, the initially hypothesized model (Figure 3) appeared to represent the data more parsimoniously than this alternative sequence of events.

Discussion

A sizeable percentage of the general public sleep less than 6 hours a night on average (Ford, Cunningham, & Croft, 2015; Jones, 2013), putting their functioning at considerable risk. Extending previous research which found sleep deprivation to have a range of psychological consequences, including mood disturbance (e.g., Kahn-Greene et al., 2007) and cognitive dysfunction (Frenda & Fenn, 2016), the present research examined the effects of insufficient sleep on two important resources of mental health, namely the capacity to be mindful and the satisfaction of individuals' basic psychological needs. Furthermore, we considered a chain of mechanisms to understand the effect of sleep deprivation, thereby examining whether increased fatigue would relate to reduced mindfulness, which then in turn would forestall need satisfaction.

Replicating a number of previous studies the present research found sleep deprivation to have an immediate impact on subjective energy (e.g., Klumpers et al., 2015), with the effects of insufficient sleep on increased fatigue already manifesting after one night of sleep deprivation. In contrast, it took longer for effects on psychological functioning to appear, with participants only reporting reduced mindfulness and decreased need satisfaction after three days of being sleep deprived. Interestingly, the induced sleep deprivation had no effect on participants' experienced need frustration, indicating that three days of being partially sleep deprived did not serve to actively frustrate individuals' basic psychological needs. Perhaps, if the manipulation of sleep duration had been prolonged across more days or had been more intense during the three-day period (e.g., less than 4 hours of sleep or total sleep loss for 24 hours) the observed effects on psychological functioning would have been more pronounced and may even have resulted in increased need frustration. For example, if sleep had been deprived across more days, individuals may have begun to feel pressured and unable to handle daily tasks and challenges and perhaps also experience more interpersonal conflict and difficulties, signifying need frustration. In line with this, previous research found that sleeping less than five hours across 7 consecutive days had cumulative and escalating effects on waking functioning (Dinges et al., 1997).

The present results extend previous work which indicated that both mindfulness (e.g., Howell et al., 2010; Kanen et al., 2015) and need-based experiences (e.g., Campbell et al., 2015; Campbell et al., 2017) are predictive of quality and quantity of sleep, by showing that sleep at night, and sleep duration in particular, can also impact on these psychological factors. Similarly, findings from a recent diary study also found daily quality and quantity of sleep to contribute to daily need-based experiences (Campbell, Vansteenkiste, et al., 2017). However, these previous findings were correlational in nature and did not allow for conclusions about the direction of effects. Overall, this body of research indicates that a cyclical effect may exist, wherein sleep deprivation undermines psychological functioning, which in turn leads to further sleep reductions.

These findings are important because they speak to the dynamic interface between individuals' physiological and psychological needs, an issue that has received very little prior attention. Also, the damaging impact of sleep deprivation on need satisfaction is worrisome from a well-being-perspective. Indeed, a large body of work indicates that the costs of low need satisfaction to physical and psychological well-being are numerous and long-lasting; for example, reductions in psychological need satisfaction have been linked to lower life satisfaction, fewer positive emotions, more depression and anxiety (see review in Ryan & Deci, 2017), and physiological arousal including greater salivary cortisol and blood pressure (Quested et al., 2011; Weinstein, Legate, Kumashiro, & Ryan, 2016). The results of the present findings suggest that accumulated sleep deprivation might indirectly lead to these adverse outcomes because it undermines psychological need satisfaction.

We also examined whether the observed reductions in subjective energy and mindfulness helped to explain why participants in the experimental group reported decreased need satisfaction after three days of sleep deprivation. In line with our hypothesized model, results revealed that reduced energy following sleep deprivation related to impaired mindfulness which, in turn, contributed to decreased need satisfaction. Although we explored the possibility that reduced energy would relate to decreased need satisfaction directly (i.e., without being accounted for by impaired mindfulness), this direct path was nonsignificant. The finding that reduced mindfulness led to lower need satisfaction is in line with previous research which found individuals low in mindfulness to report less need satisfaction (Brown & Ryan, 2003; Campbell et al., 2015); whereas in previous research mindfulness was examined as an individual difference characteristic here we found that variations were present from day to day. There are several possible reasons why reduced impaired present moment awareness on a given day predicts reduced need satisfaction. When low in mindfulness, individuals may be less able to effectively and wholeheartedly engage in daily activities and thus be less able to derive need satisfaction from these activities. In addition, impaired mindfulness likely leaves individuals less in tune with their interests and values, resulting in them less proactively selecting and engaging in potentially need satisfying activities, as well as less responsive to opportunities for need satisfaction throughout the day. Furthermore, given that mindfulness has been shown to mitigate emotional reactivity (Ortner, Kilner, Zelazo, 2007), it is also possible that reduced mindfulness may undermine people's capacity to effectively regulate negative emotions that stem from encountered need-frustrating experiences, which may aggravate the resulting need-frustration.

In a supplementary analysis we explored an alternative sequence, namely whether the fact that participants reported impaired psychological functioning after three days of sleep deprivation would contribute to further reductions in subjective energy. Importantly, this effect was obtained above and beyond the effect of sleep deprivation, which indeed had a substantial impact on individuals' increased fatigue. Yet, participants' fatigue also stemmed from their reduced mindfulness following sleep deprivation. This suggests that although people often tend to attribute their increased fatigue after a night of sleep deprivation to the lack of sleep itself, it seems that psychological mechanisms are at play that may exacerbate the experienced fatigue. That is, when low in mindfulness, people may become more easily distracted by their thoughts and emotions during ongoing activities and it then requires energy for them to re-center themselves into the present moment, which in itself may be draining. Overall these results suggest that impaired subjective energy following sleep deprivation may not only be predictive of but may also be predicted by impaired mindfulness.

Notably, reduced mindfulness had a direct relation with increased fatigue, an effect that was not accounted for by reduced psychological need satisfaction. This null-relation is surprising in light of previous work that found need satisfaction to predict individuals' energy levels (e.g., Chen et al., 2015, Van den Broeck, Vansteenkiste, De Witte, & Lens, 2008). It remains to be seen whether this effect can be replicated in future research or whether it only emerges under these rather specific circumstances.

Limitations and Directions for Future Research

The present study had some limitations. First, as a result of our effort to create a homogeneous, well-functioning sample, the final sample was fairly small and consisted mainly of women. The sample was also subject to self-selection bias as all individuals knew before agreeing to participate that there was a possibility that they would be required to deprive their sleep; those who may have coped even worse with sleep deprivation might have self-selected out of the study. If this is the case, we might expect detrimental impacts of sleep deprivation to be even stronger in the general population. Furthermore, because all participants were screened for sleep disturbances and depressive symptoms the sample was relatively healthy and may not generalize well to clinical populations. Thus, it would be interesting to examine whether these results can be replicated among larger, more heterogeneous samples and perhaps also among individuals who are used to routinely sleeping less, such as shift workers. In addition, subjective energy and psychological functioning were only assessed once each evening. Future research could use experience sampling methodology (e.g., Shiffman, Stone, & Hufford, 2008) to collect multiple daily assessments using a smart phone application (e.g., Runyan et al., 2013) that provide a understanding of how these processes are related within the day. For example, it might be that costs to psychological functioning are seen more in the afternoons and evenings, when initial energy levels have been depleted. Future experimental studies could also examine the effect of insufficient sleep on more varied indicators of cognitive functioning such as decision making, creative thinking or problem solving, and examine whether these effects are explained by impaired mindfulness following sleep deprivation. In addition, future experimental studies could examine whether manipulating sleep quality has a similar or more pronounced effect on psychological functioning, by for example waking participants up at regular intervals throughout the night (e.g., Finan, Quartana, & Smith, 2015) to disrupt sleep continuity. Finally, in light of the present findings, future studies could examine whether participation in a low-dose mindfulness intervention (e.g., Hülsheger, Feinholdt, & Nübold, 2015) protects participants against the detrimental effects of sleep deprivation.

Conclusion

The present experimental study revealed that three days of partial sleep deprivation (i.e., sleeping less than 5 hours a night) resulted in impaired mindfulness and decreased need satisfaction, thereby underscoring the detrimental impact of consistently sleeping less than recommended on two important resources of mental health. The findings further indicate that the relation between sleep deprivation and decreased need satisfaction was accounted for (i.e., explained) by increased fatigue and subsequent impairments in individuals' capacity to be mindful. These findings build on previous research by showing that mindfulness and need-based experiences may not only precede but may also follow from sleep at night.

References

Anderson, C., & Horne, J. A. (2006). Sleepiness enhances distraction during a monotonous task. *Sleep, 29*, 573-576.

Bartholomew, K. J., Ntoumanis, N., Ryan, R. M., & Thøgersen-Ntoumani, C. (2011). Psychological need thwarting in the sport context: Assessing the darker side of athletic experience. *Journal of Sport & Exercise Psychology, 33*, 75-102.

Beck, A. T., Steer, R. A., & Brown, G. K. (1996). Manual for the Beck Depression Inventory-II. San Antonio, TX: Psychological Corporation.

Beyers, W., & Goossens, L. (2008). Dynamics of perceived parenting and identity formation in late adolescence. *Journal of Adolescence, 31*, 165-184. doi: 10.1016/j.adolescence.2007.04.003.

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology*, *84*, 822–848.

Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index – a new instrument for psychiatric practice and research. *Psychiatry Research*, *28*, 193–213.

Campbell, R., Tobback, E., Delesie, L., Vogelaers, D., Mariman, A., & Vansteenkiste, M. (2017). Basic psychological need experiences, fatigue, and sleep in individuals with unexplained chronic fatigue. *Stress & Health*.

Campbell, R., Vansteenkiste, M., Delesie, L.M., Mariman, A. N., Soenens, B., Tobback, E., Van der Kaap-Deeder, J., & Vogelaers, D. P. (2015). Examining the role of psychological need satisfaction in sleep: A Self-Determination Theory perspective. *Personality and Individual Differences, 77*, 199-204.

Campbell, R., Vansteenkiste, M., Delesie, L. M., Soenens, B., Tobback, E., Vogelaers, D., & Mariman, A. (2016). The role of psychological need satisfaction, sleep, and mindfulness in the health related quality of life of people living with HIV. *Journal of Health Psychology.*

Campbell, R., Vansteenkiste, M., Soenens, B., Vandenkerckhove, B., & Mouratidis, A. Examining daily variation in adolescent sleep: The role of psychological need experiences. *Manuscript submitted for publication.*

Chen, B., Vansteenkiste, M., Beyers, W., Boone, L., Deci, E. L., Duriez, B. Lens, W., Matos, L., Mouratidis, A., Ryan, R. M., Sheldon, K. M., Soenens, B., Van Petegem, S., & Van der Kaap-Deeder, J., & Verstuyf, J (2015). Basic psychological need satisfaction, need frustration, and need strength across four cultures. *Motivation and Emotion, 39,* 216-236.

Chiesa, A., & Serretti, A. (2009). Mindfulness-based stress reduction for stress management in healthy people: A review and meta-analysis. *Journal of Alternative and Complimentary Medicine, 15,* 593-600.

Davidson, R. J., Kabat Zinn, J., Schumacher, J., Rosenkranz, M., Muller, D., Santorelli, S. F. & Sheridan, J. F. (2003). Alterations in brain and immune function produced by mindfulness meditation. *Psychosomatic Medicine*, *65*,564-570.

Deci, E. L. & Ryan, R. M. (2000). The 'what' and 'why' of goal pursuits: Human needs and the self determination of behavior. *Psychological Inquiry*, *11*, 227-268.

Dinges, D. F., Pack, F., Williams, K., Gillen, K. A., Powell, J. W., Ott, G. E., Aptowicz, C., & Pack, A. I. (1997). Cumulative sleepiness, mood disturbance, and psychomotor vigilance performance decrements during a week of sleep restricted to 4–5 hours per night. *Sleep*, *20*, 267-277.

Finan, P. H., Quartana, P.J., & Smith, M.T. (2015). The effects of sleep continuity disruption on positive mood and sleep architecture in healthy adults. *Sleep*,*38*, 1735-1742.

Ford, E.S., Cunningham, T.J., & Croft, J.B. (2015). Trends in self-reported sleep duration among US adults from 1985 to 2012. *Sleep, 38,* 829-832.

Frenda, S.J. & Fenn, K.M. (2016). Sleep less, think worse: The effect of sleep deprivation on working memory. *Journal of applied research in memory and cognition, 5,* 463-469.

Harrision, Y., Horne, J.A. (2000). The impact of sleep deprivation on decision making: A review. *Journal of Experimental Psychology: Applied*, *6*, 236-249.

Hertzog, C., Dixon, R. A., Hultsch, D. F., & MacDonald, S. W. S. (2003). Latent change models of adult cognition: Are changes in processing speed and working memory associated with changes in episodic memory? *Psychology and Aging, 18,* 755-769. doi: 10.1037/0882-7974.18.4.755

Howell, A. J., Digdon, N. L., & Buro, K. (2010). Mindfulness predicts sleep-related self-regulation and well-being. *Personality and Individual Differences*, *48*, 419-424.

Howell, A. J., Digdon, N. L., Buro, K., & Sheptycki, A. R. (2008). Relations among mindfulness, well-being, and sleep. *Personality and Individual Differences, 45*, 773-777.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6,* 1-55.

Hülsheger, U. R., Feinholdt, A., & Nübold, A. (2015). A low-dose mindfulness intervention and recovery from work: Effects on psychological detachment, sleep quality, and sleep duration. *Journal of Occupational and Organizational Psychology, 88,* 464-489.

Jones, J. (2013, December 5-8) In U.S., 40% get less than recommended amount of sleep. Retrieved from http:// http://www.gallup.com/poll/166553/less-recommended-amount-sleep.aspx.

Kahn-Greene, E. T., Killgore, D.B., Kamimori, G.H., Balkin, T.J., & Killgore, W.D.S. (2007). The effects of sleep deprivation on symptoms of psychopathology in healthy adults. *Sleep Medicine,* ?, 215-221.

Kanen, W. J., Nazir, R., Sedky, K., & K Pradhan, B. (2015). The effects of mindfulness-based interventions on sleep disturbance: A meta-analysis. *Adolescent Psychiatry*, *5*, 105-115.

Kline, R. B. (2005). *Principles and practice of structural equation modeling*. New York: Guilford Press.

Klumpers, U. M. H., Veltman, D. J., Van Tol, M. J., Kloet, R. W., Boellaard, R., Lammerstsma, A. A., & Hoogendijk, W. J. G. (2015). Neurophysiological effects of sleep deprivation in healthy adults, a pilot study. *PLoS ONE, 10*: e0116906.

Little, T. D., Cunningham, W. A., Shahar, G., & Widaman, K. F. (2002). To parcel or not to parcel: Exploring the question, weighing the merits. *Structural Equation Modeling, 9,* 151–173.

Lundh, L.-G. (2005). The role of acceptance and mindfulness in the treatment of insomnia. *Journal of Cognitive Psychotherapy*, *19,* 29–39.

Martela, F., & Ryan, R. M. (2016). Prosocial behavior increases well-being and vitality even without contact with the beneficiary: Causal and behavioral evidence. *Motivation and Emotion*, *40,* 351-357.

Minkel, J., Moreta, M., Muto, J., Htaik, O., Jones, C., Basner, M., & Dignes, D. (2014). Sleep deprivation potentiates HPA axis stress reactivity in healthy adults. *Health Psychology, 33,*1430-1434.

Ortner, C. N. M., Kilner, S. J., & Zelazo, P. D. (2007). Mindfulness meditation and reduced emotional interference on a cognitive task. *Motivation and Emotion, 31*, 271–283.

Pires, G. N., Bezerra, A. G., Tufik, S., & Andersen, M. L. (2016). Effects of acute sleep deprivation on state anxiety levels: a systematic review and meta-analysis. *Sleep Medicine, 24,* 109-118.

Poh, J. H., Chong, P. L. H., & Chee, M. W. L. (2016). Sleepless night, restless mind: Effects of sleep deprivation on mind wandering. *Journal of Experimental Psychology: General*, *145*, 1312-1318.

Quested, E., Bosch, J. A., Burns, V. E., Cumming, J., Ntoumanis, N., & Duda, J. L. (2011). Basic psychological need satisfaction, stress-related appraisals, and dancers' cortisol and anxiety responses. *Journal of Sport & Exercise Psychology*, *33,* 828-846.

Reibel, D., Greeson, J., Brainard, G., & Rosenzweig, S. (2001). Mindfulness-based stress reduction and health-related quality of life in a heterogeneous patient population. *General Hospital Psychiatry, 23*, 183-192.

Reis, H. T., Sheldon, K. M., Gable, S. L., Roscoe, J., & Ryan, R. M. (2000). Daily well-being: The role of autonomy, competence, and relatedness. *Personality and Social Psychology Bulletin*, *26*, 419-435.

Runyan, J., Steenbergh, T., Bainbridge, C., Daugherty, D., Oke, L., & Fry, B .(2013). A smartphone ecological momentary assessment intervention “App” for collecting real-time data and promoting self-awareness. *PLOS/one*.doi:10.1371/journal.pone.007132 5.

Ryan, R. M., & Deci, E. L. (2017). *Self-Determination Theory: Basic psychological needs in motivation, development, and wellness*. New York: Guilford.

Shiffman, S., Stone A., & Hufford, M. (2008). Ecological momentary assessment. *Annual Review of Clinical Psychology,* 4,1–32.

Sörbom, D. (1975). Detection of correlated errors in longitudinal data. *British Journal of Mathematical and Statistical Psychology, 28,* 138-151.

Van den Broeck, A., Vansteenkiste, M., De Witte, H., Lens, W. (2008). Explaining the relationships between job characteristics, burnout, and engagement: The role of basic psychological need satisfaction. *Work & Stress, 22,* 277-294.

Van der Kaap-Deeder, J., Vansteenkiste, M., Soenens, B., & Mabbe, E. (2017). Children’s daily well-being: The role of mothers’, teachers’, and siblings’ autonomy support and psychological control. *Developmental psychology*, *53*(2), 237.

Vansteenkiste, M., & Ryan, R. M. (2013). On psychological growth and vulnerability: Basic psychological need satisfaction and need frustration as a unifying principle. *Journal of Psychotherapy Integration, 23,* 263-280.

Vollestad, J., Nielsen, M. B., & Nielsen, G. H. (2012). Mindfulness and acceptance based interventions for anxiety disorders: A systematic review and meta-analysis. *British Journal of Clinical Psychology, 51*, 239-260.

Watson, N. F., Badr, M. S., Belenky, G., Bliwise, D. L., Buxton, O. M., Buysse, D., Dinges, D. F., Gangwisch, J., Grandner, M. A., Kushida, C., Malhotra, R. K., Martin, J. L., Patel, S. R., Quan, S. F., Tasali, E. (2015) Recommended amount of sleep for a healthy adult: a joint consensus statement of the American Academy of Sleep Medicine and Sleep Research Society. *Sleep*, *38*, 843–844.

Watson, D., O'Hara, M. W., Simms, L. J., Kotov, R., & Chmielewski, M. (2007). Development and validation of the Inventory of Depression and Anxiety Symptoms (IDAS). *Psychological Assessment*, *19*, 253–268.

Weinstein, N., Legate, N., Kumashiro, M., & Ryan, R. M. (2016). Autonomy support and diastolic blood pressure: Long term effects and conflict navigation in romantic relationships. *Motivation and Emotion*, *40*, 212-225.

CHAPTER 9

General Discussion

The global objective of the present dissertation was to systematically examine the association between the satisfaction and frustration of the basic psychological needs for autonomy, competence and relatedness, as conceived within Self-Determination Theory (SDT; Deci & Ryan, 2000; Ryan & Deci, 2017), and diverse sleep outcomes. In addition, we sought to examine the mechanisms underlying these associations, as well as to explore the possible reciprocal and causal associations between need-based experiences and sleep. Finally, we also investigated the role of mindfulness in promoting need fulfillment and subsequent sleep outcomes. These objectives were pursued throughout a series of cross-sectional, diary, and experimental studies in both non-clinical and clinical samples using a multimethod and differentiated approach to measuring sleep. In this general discussion we begin by providing an overview of the key findings of the present dissertation. In doing so, different parts of each study are discussed under the different objectives. Thus, rather than discussing findings in a study-wise fashion, we cut across several studies within each objective thereby selectively discussing the findings from different studies as they are relevant to the objective being discussed. In doing so, we hope to bring further clarity, that is, we aim to highlight the communalities and differences in the findings across studies and to indicate how different studies form a complementary whole, thereby cumulatively building on each other. With these key findings in mind, we then reflect on the theoretical implications of these findings, thereby acknowledging the main limitations of the conducted studies, and also suggesting directions for future research. Finally, we end this chapter by discussing the clinical implications of the findings and providing a general conclusion.

Table of Contents

2.4. Reflections on the Role of Mindfulness (Objective 5).

2.4.1. The Salutary Role of Mindfulness

2.4.1. Future Directions

3. Clinical Implications of the Findings

3.1. Current Clinical Approach

3.2. Clinical Approach Grounded in SDT and the Present Dissertation

3.3. Need Frustration as a Transdiagnostic Risk Factor

4. General Conclusion

5. References

1. General Overview of the Findings

1.1. Objective 1: To Examine the Relation between Psychological Need-Based Experiences and Diverse Sleep Outcomes at both the Between- and Within-Person Level.

In light of the paucity of previous studies examining the role of basic psychological needs in predicting individuals' sleep, the first objective of the present dissertation was to examine the extent to which a relationship actually exists between need-based experiences and diverse sleep outcomes in non-clinical samples, an issue that deserves attention at both the between- and within-person level. In Chapter 2, a cross-sectional design was used to collect initial evidence for the hypothesized need-sleep relation in a heterogeneous, healthy adult sample. Findings indicated that a composite score of psychological need satisfaction related negatively to poor sleep quality and daytime dysfunction but was only minimally associated with sleep quantity. These initial results not only provided preliminary evidence for the association between psychological need satisfaction and quality and (to a lesser extent) quantity of sleep but also supported the idea that a heterogeneous approach to assessing sleep is warranted as the strength of the need satisfaction-sleep association depended on the outcome under investigation.

Given that individuals' sleep may vary as a function of encountered stressors, in Chapter 3 we moved from a between-person to a within-person design by conducting a short-term longitudinal in which emerging adults' need-based experiences (i.e., their satisfaction and frustration), sleep and daytime functioning was assessed before, during, and after exposure to a potential stressor (i.e., an exam period). An examination of the mean-level changes in the outcomes indicated that as participants moved from the pre- to the exam period their need-based, sleep and daytime functioning deteriorated and then returned to and even went beyond initial levels when the exam period was over. Importantly, this design also allowed for an examination of the co-variation between the need, sleep, and daytime outcomes across time, that is, it allowed us to address the question of whether changes in need-based experiences and changes in the sleep-related outcomes occur in tandem across measurement moments. Correlated change analyses revealed that as participants' need satisfaction decreased and need frustration increased from the pre- to the exam period, their sleep quality and daytime functioning worsened, whereas subsequent increases in need satisfaction and decreases in need frustration from the exam to the post exam period were accompanied by improvements in sleep quality and daytime functioning. Notably, similar to Chapter 1, the association between changes in need-based experiences and changes in sleep quantity was less robust. Specifically, increases in need frustration were only associated with decreases in sleep quantity from the pre- to the exam period, whereas changes in need frustration were unrelated to changes in sleep quantity from the exam to the post exam period. Furthermore, changes in need satisfaction were also unrelated to changes in sleep quantity across both transitions.

While the design used in Chapter 3 spanned three months and involved three repeated measurement moments, in Chapter 7 the time interval between consecutive measurement moments was reduced. That is, two diary studies were conducted among adolescents which continued to address the question of whether need-based experiences co-vary with sleep-related outcomes, this time by examining their co-variation from day to day. Specifically, we examined whether day to day (i.e., within-person) variability in need satisfaction- and frustration would contribute to daily variation in fatigue and quality and quantity of sleep. In contrast to the previously discussed short-term longitudinal study in which the role of need satisfaction- and frustration was examined separately, in Chapter 7 we investigated their unique contributions by entering them both simultaneously in the prediction of the outcomes. Results of both studies revealed that daily experiences of need frustration, rather than daily need satisfaction, played a more prominent role in the prediction of the sleep-related outcomes, as daily need frustration not only related to more daily fatigue, but also related to poorer daily sleep quality and shorter daily sleep quantity. Importantly, the findings from the second study reported in Chapter 7 indicated that the day to day association between need frustration and sleep was not limited to self-reported sleep outcomes, but also extended to an objective indicator of sleep, namely sleep quantity as assessed by wrist actigraphy.

In sum, using cross-sectional, longitudinal and diary designs, these studies provided initial evidence among various non-clinical samples (i.e., adolescents, emerging adults, & adults) that need-based experience do indeed relate to diverse sleep-related outcomes at both the between- and within-person level. Furthermore, the findings indicated that the strength of the observed association was dependent on the outcome under investigation, with the association with sleep quality being most pronounced. Overall, these findings demonstrated that individuals who experienced less need satisfaction in their lives in general reported poorer sleep quality and that more need frustration from week to week and from day to day than usual also related to poorer sleep quality.

1.2. Objective 2: To Examine whether the Observed Findings Generalize to Clinical Groups in which Sleep Disturbances are Highly Prevalent.

Although findings from Objective 1 indicated that need-based experiences were indeed systematically related to sleep-related outcomes in diverse populations, using diverse designs and methods to assess sleep, it remained to be seen whether these finding would generalize to clinical groups who suffer from sleep disturbances. The SDT framework allows for the formulation of hypotheses in this context as it claims that the basic psychological needs for autonomy, competence, and relatedness are universal. Thus, within SDT the satisfaction of these three psychological needs is said to bring about salutary outcomes whereas the frustration of these same needs is said to elicit impoverished functioning among all individuals regardless of their background or clinical status. In line with SDT’s universality claim, our second objective was to examine whether the observed findings would indeed generalize to clinical samples in which physical functioning is compromised and sleep disturbances are highly prevalent.

In Chapter 4 we used a cross-sectional design to examine whether the need-sleep relation identified in Chapter 2 (i.e., among a non-clinical sample of healthy adults) would also extend to people living with HIV (PLHIV). Given that health-related quality of life (HRQOL) is an important outcome in HIV research (Lin, Wu & Revicki, 2002) and that previous studies suggest that need satisfaction may be implicated in the HRQOL of PLHIV (e.g., Quinlivian, Messer, Adimora, et al., 2013), our central focus in Chapter 4 was to first examine the association between a composite score of psychological need satisfaction and indicators of HRQOL. Following this, we examined whether the association between need satisfaction and HRQOL could be accounted for (i.e., explained) by quality and quantity of sleep. Findings revealed that need satisfaction related positively to global physical and mental health. Furthermore, poor sleep quality fully accounted for the association with global physical health and partially accounted for the relation with global mental health. Interestingly, sleep quantity was unrelated to both need satisfaction and physical and mental health.

While HIV patients are known to suffer from worse health-related quality of life, which partially stems from their poorer sleep quality (Phillips et al., 2005; Phillips et al., 2006), in Chapter 5 we sampled patients reporting complaints of unexplained chronic fatigue. This population is different from the HIV-population because their main presenting complaint is persistent chronic fatigue which has previously been unexplained by any underlying medical or psychiatric condition. Different to the cross-sectional design used in Chapter 4 among the HIV sample, in Chapter 5 we employed a prospective cross-sectional design to examine the unique role of need satisfaction- and need frustration in the prediction of subjective and objective sleep outcomes. Specifically, a group of individuals undergoing clinical investigation for complaints of unexplained chronic fatigue rated their need-based experiences from the past week and underwent Polysomnography (PSG) during a stay at a sleep laboratory which objectively assessed their sleep. Results indicated that more need frustration during the past week, rather than a lack of need satisfaction, was indirectly related to poorer subjective sleep quality and shorter sleep duration during a night spent in a sleep laboratory via a chain of mediating mechanisms (to be discussed under Objective 3). Importantly, these indirect associations emerged in relation to both subjective and objective shorter total sleep time and subjective (but not objective) longer sleep latency. Hence, these findings indicated that need frustration not only related to subjective reports of quality and quantity of sleep but also related to objective quantitative sleep indicators derived from PSG, a finding which is consistent with the results obtained in the diary study conducted among non-clinical adolescents in Chapter 7.

While participants in Chapter 5 were suffering from symptoms of unexplained chronic fatigue and, hence, represented a more heterogeneous sample, individuals who participated in Chapter 6 were formally diagnosed with Chronic Fatigue Syndrome (CFS) and as a result were a more homogeneous group. In Chapter 6, rather than relying on a between-person design, we employed a diary methodology to examine whether the previously observed association between need-based experiences and sleep would also apply at the within-person level among individuals with CFS. Given that fatigue is the central complaint among individuals with CFS, and that previous studies have consistently shown need-based experiences to relate to individuals subjective energy (e.g., Chen et al., 2015; Ryan & Deci, 2008), we began by examining whether day to day variation in need satisfaction- and frustration would relate to daily variation in subjective energy (i.e., fatigue & vitality). Next, we examined the role of these same daily need-based experiences in predicting daily quality and quantity of sleep, as reported the following morning. Multilevel analyses indicated that daily need satisfaction related to less daily fatigue and more daily vitality whereas the opposite pattern was observed for daily need frustration. Daily need frustration also related to poorer daily sleep quality but was unrelated to daily sleep quantity, whereas daily need satisfaction appeared to be unrelated to both daily quality and quantity of sleep. Thus, these findings indicated that both daily need satisfaction and daily need frustration were implicated in daily fluctuations in CFS patients’ energy levels, whereas only daily need frustration played a role in contributing to day to day variation in sleep quality.

To summarize, the critical role of need-based experiences in the prediction of sleep-related outcomes, for which initial evidence was obtained among non-clinical samples as part of Objective 1, was largely confirmed among diverse clinical populations. As shown in Table 1, irrespective of the design used, the contribution of need-based experiences to energy-related outcomes (i.e., fatigue, vitality) was most robust, while the effects on sleep quality and especially sleep quantity were less strong and appeared to be more indirect in some studies. That is, a chain of intervening mechanisms needed to be included to understand why need-based experiences relate to sleep quality and quantity, an issue which we turn to next.

Table 1

Overview of findings from Objectives 1, 2 & 3

Predictor	Study	Sample	Stress	Negative sleep-related cognitions	Subjective energy	Sleep quality	Sleep quantity	
							Self-report	Objective
Need composite	1	Non-clinical adults	NA	NA	+	+	+	NA
Need composite	3	HIV patients	NA	NA	NA	+	0	NA
Need satisfaction Need frustration	2	Non-clinical emerging adults	-/- +/+	NA	+/+ -/-	+/+ -/-	0/0 -/0	NA
Need satisfaction Need frustration	4	Individuals with unexplained chronic fatigue	0 +	0 +*	0 -*	0 -*	0 -*	0 -*
Need satisfaction Need frustration	5	Chronic Fatigue Syndrome patients	NA	NA	+ -	0 -	0 0	NA
Need satisfaction Need frustration	6	Non-clinical adolescents	NA	NA	+ -	0 -	0 -	NA
Need satisfaction Need frustration	7	Non-clinical adolescents	0 +	NA	0 -	0 -*	NA	0 -*

Note. + = significant positive association; - = significant negative association 0 = non-significant association;
* = indirect relation; NA = not assessed.
In study 2 need satisfaction and need frustration were examined separately in the prediction of the outcomes. Also with respect to Study 2 the symbol before the line refers to the transition from pre- to exam period and symbol after the line refers to the transition from the exam to the post exam period.

1.3. Objective 3: To Explore Stress and Negative Sleep-related Cognitions as Explanatory Processes.

Having identified that there is indeed an association between need-based experiences and diverse sleep outcomes among non-clinical (i.e., Objective 1) and clinical (i.e., Objective 2) samples, our third objective was to uncover the explanatory mechanisms which account for (i.e., explain) the observed need-sleep association. In line with several theories of chronic sleep disturbances (e.g., Espie, Broomfield, MacMahon, Macphee, & Taylor, 2006; Harvey, 2002; Riemann, et al., 2010) which posit stress and dysfunctional cognitive processes as playing a role in the precipitation and maintenance of poor sleep, throughout the present dissertation we examined the potential explanatory role of symptoms of stress, such as tension, nervous arousal and difficulty relaxing, as well as negative sleep-related thoughts (i.e., ruminating about the consequences of not getting enough sleep) in the relation between need-based experiences and sleep outcomes.

In Chapter 3 we began by examining the explanatory role of stress in the short-term longitudinal study in which university students were assessed before, during, and after an exam period. A first set of findings that are indicative of the role of stress involves the systematic mean-level differences in experienced stress, need-based experiences and sleep-related outcomes as a function of emerging adults' exposure to the potential stressor. That is, the peak in their experienced stress was observed during the exam period which coincided with the lowest scores in need satisfaction and sleep quality and the highest scores in need frustration. Findings indicated significant mean level changes in stress across both transitions, with participants reporting increases in stress as they moved from the pre- to the exam period and decreases in stress as they went from the exam to the post exam period. In an attempt to provide more direct evidence for the explanatory role of stress, we examined the intervening role of stress in the co-variation between need-based experiences and the sleep and day-time outcomes across time through correlated change analyses. Hypotheses were fully confirmed. That is, the finding that an increase in need frustration and a decrease in need satisfaction from the pre- to the exam period was accompanied by an increase in poor sleep quality was completely explained by the increase in experienced stress during this transition. These findings provided preliminary evidence for the critical explanatory role of stress in the need-sleep association.

Stress levels not only vary from one point in time to another as a function of encountered stressors, but can also vary on a day to day basis (Galambos, Dalton, & Maggs, 2009). Therefore, in Chapter 7 we continued to examine the explanatory role of stress, this time in the day to day association between need-based experiences and sleep. Specifically, in the second study reported in Chapter 7 we examined whether day to day variation in symptoms of stress would account for the observed day to day relation between daily need-based experiences and the daily sleep-related outcomes among adolescents. Results indicated that daily need frustration, rather than low daily need satisfaction, related to symptoms of stress, which in turn contributed to more daily fatigue, poorer daily sleep quality and shorter objective sleep quantity, the latter of which was assessed by wrist actigraphy. These findings yielded further evidence for the critical explanatory role of stress in the relation between need frustration and not only subjective (i.e., sleep quality) but also objective (i.e., sleep quantity) sleep outcomes.

In contrast to Chapter 3 and Chapter 7 in which we only examined the intervening role of stress, in Chapter 5 we additionally focused on the explanatory role of negative sleep-related cognitions (Fichten et al., 1998) in a sample of individuals with unexplained chronic fatigue. We deemed the inclusion of this explanatory variable critical because the measure we used to assess stress was primarily concerned with day-related experiences, whereas negative sleep-related cognitions refer to people's sleep-interfering thoughts prior to going to bed which presumably stem from day-related stress. As such, sleep-related cognitions are more proximally related to individuals' sleep. In Chapter 5, participants with unexplained chronic fatigue rated their need-based experiences and stress during the past week in the evening of a one-night stay at a sleep laboratory for polysomnography. In addition, the extent to which they experienced negative sleep-related cognitions before falling asleep was assessed when they woke up in the morning, as well as their self-reported quality and quantity sleep. Despite the different sample, design, and method used to assess sleep, the pattern of findings which emerged largely mirrored and, hence, replicated the pattern obtained in the diary study among adolescents. Specifically, findings indicated that need frustration during the past week, rather than a lack of need satisfaction, related to higher stress during the preceding week, which in turn related to higher evening fatigue. Findings further indicated that higher symptoms of stress and more subsequent negative sleep-related cognitions during the stay at the sleep lab explained the relation between higher need frustration during the past week and poorer subjective sleep quality and shorter sleep duration.

To summarize, the present dissertation undertook some first steps to shed light on why it is that need-based experiences relate to sleep outcomes. Although a variety of mechanisms may be involved, the present findings provide evidence for the explanatory role of stress and negative pre-sleep cognitions in the relation between need-based experiences and sleep outcomes. The role of these two processes may be both unique and complementary in the sense that stress may especially account for the need-fatigue association, while the combination of both processes may help to explain why need-frustrating experiences in particular relate to poor sleep quality and shorter sleep quantity.

1.4. Objective 4: To Collect Evidence for the Reciprocal and Casual Relation between Psychological Need-Based Experiences and Sleep Outcomes.

In light of the abundance of previous studies (e.g., Fuligni & Hardway, 2006; Galambos et al., 2009) which indicate that sleep at night contributes to individuals' psychological functioning the following day, our fourth objective was to examine the reciprocal and causal relation between need-based experiences and sleep. Indeed, the need-sleep relation is unlikely to be a one way street. While the focus in the previous objectives was primarily on need-based experiences predicting sleep, we fully recognize that the quality and quantity of individuals' sleep may also contribute to individuals' need-based experiences as well as their psychological functioning in general. Within the present dissertation, this issue of reciprocity was pursued throughout two types of studies, namely diary studies (i.e., in Chapter 6 and Chapter 7) and an experimental study (i.e., in Chapter

8). While the diary studies allowed for an examination of the *reciprocal* relation between daily need-based experiences and sleep at night, the experimental study allowed for stricter inferences about the actual *causal* association between sleep and daily need-based functioning. In Chapter 6, we began by examining whether quality and quantity of sleep at night would contribute to day to day variation in daily need-based experiences among patients with Chronic Fatigue Syndrome (CFS). Results revealed that morning reports of poorer sleep quality related to less daily need satisfaction and more daily need frustration, as reported in the evening. However, day to day variation in sleep quantity was unrelated to next day need experiences. In Chapter 7, we continued to examine the reciprocal day to day association between daily need-based experiences and sleep, this time through two diary studies conducted among adolescents. Findings from the first diary study indicated that morning reports of both poorer sleep quality and shorter sleep quantity related to more need frustration, as reported in the evening. The second diary study partially replicated these findings by similarly demonstrating that morning reports of poorer sleep quality were associated with more need frustration the next day, however, day to day variability in objectively assessed sleep quantity (i.e., assessed through wrist actigraphy) was unrelated to next day need experiences. Overall, these studies provided evidence for the reciprocal relation between sleep at night, and subjective sleep quality in particular, and daily-based experiences.

While the three diary studies in Chapter 6 and Chapter 7 examined the relation between *naturally occurring* day to day variation in quality and quantity of sleep and next day need-based experiences, in Chapter 8 we examined the effects of *experimentally induced* sleep debt. While a third unmeasured variable may account for the relation between sleep and need-based experiences in the diary studies, the strict randomization procedure applied in Chapter 8 limited the possibility of a third variable contaminating the findings. While the separate role of both sleep quantity and quality was addressed in the diary studies, the experimental study involved a reduction in the *quantity* of individual's sleep. Yet, the intensity of the sleep deprivation was more extreme than the average deviations observed in the diary research. Specifically, in the experimental study, healthy adults were required to sleep less than 5 hours a night for three consecutive days. Apart from examining the effect on need-based experiences, we also investigated whether mindfulness would be impaired under these circumstances. Indeed, previous studies indicate that insufficient sleep is likely to have a detrimental effect on individual's attentional capacities (e.g., Anderson & Horne, 2006; Poh, Chong, & Chee, 2016). Findings revealed that although participants reported significantly increased fatigue after one day of being sleep deprived, it took three days of sleep deprivation before they reported reduced need satisfaction and impaired mindfulness.

To summarize, these studies provide some evidence that psychological need-based experiences and quality and quantity of sleep are indeed reciprocally related. In particular, in the diary studies it appeared that poorer sleep quality, rather than shorter sleep quantity, was more consistently predictive of experiences of need frustration the following day among both non-clinical (i.e., adolescents) and clinical (i.e., CFS patients) samples. While in the diary studies we examined the role of naturally occurring day to day variation in sleep quantity, in the experimental sleep deprivation study we examined the role of experimentally induced sleep debt in predicting need-based experiences. Findings indicated that three consecutive days of experimentally induced sleep debt (i.e., less than 5 hours of sleep per night) led to reduced need satisfaction, suggesting that for sleep debt to impact on individuals' need-based functioning it may need to be accumulated across days.

1.5. Objective 5: To Examine whether Mindfulness Relates to Sleep Outcomes via Need Satisfaction.

Given that previous research has found mindfulness (i.e., open present moment awareness) to display a salutary relation with sleep outcomes (e.g., Howell, Digdon, & Buro, 2010; Howell, Digdon, Buro, & Sheptycki, 2008) and that mindfulness has also been linked to higher need satisfaction (e.g., Brown & Ryan, 2003), our fifth objective was to build on previous research by examining the explanatory role of need satisfaction in the relation between mindfulness and diverse sleep outcomes. Specifically, in Chapter 2 and Chapter 4 we examined whether a composite score of psychological need satisfaction would account for (i.e., explain) the relation between trait-differences in mindfulness and sleep. In Chapter 2 findings from the cross-sectional study among healthy adults revealed that mindfulness related to better sleep quality and less daytime dysfunction but was unrelated to sleep quantity. Importantly, the relation between mindfulness and better sleep quality was completely accounted for by higher need satisfaction, whereas the relation with daytime dysfunction was only partially accounted for by higher need satisfaction. In Chapter 4 these findings were replicated. Specifically, in the cross-sectional study conducted among people living with HIV mindfulness was found to relate to better sleep quality but again, was unrelated to sleep quantity. Furthermore, results revealed that the salutary association between mindfulness and sleep quality was completely accounted for by need satisfaction. Overall, these findings provide evidence for the role of mindfulness in promoting need fulfillment and subsequent sleep quality.

In Chapter 8 we approached the role of mindfulness from a complimentary perspective: that is, given that sleep also reciprocally impacts on need-based experiences, it is possible that mindfulness may help to explain why experimentally induced sleep debt impacts negatively on need-based experiences. Conceiving mindfulness as a variable state (Brown & Ryan, 2003), we examined whether experimentally induced sleep debt predicts state differences in mindfulness among healthy adults, which then relate to need-based experiences in the day. Findings indicated that following three days of partial sleep deprivation, participants reported impaired mindfulness, which in turn, related to decreased need satisfaction.

To summarize, this initial work on the role of mindfulness in the need-sleep association is promising as it may both serve as a predictor of need-based experiences and subsequent sleep and follow from partial sleep deprivation. Presumably, mindfulness is intertwined within this sleep-need dynamic in a complex way, an issue that will be discussed more deeply in the following section.

2. Theoretical and Methodological Reflections on the Findings

2.1. Reflections on the Role of Need-based Experiences in Sleep in Non-Clinical and Clinical Samples (Objective 1 & Objective 2)

2.1.1. Need-Sleep Relation

Within SDT, satisfaction of the basic psychological needs for autonomy, competence, and relatedness is claimed to be essential for psychological growth, well-being and optimal functioning (Ryan & Deci, 2017). Numerous previous studies have supported these claims by consistently demonstrating an association between the satisfaction of these needs and indicators of well-being at both the between-person (e.g., Chen et al., 2015) and within-person level (e.g., Ryan, Bernstein, & Brown, 2010). However, the majority of previous studies have tended to focus exclusively on the role of SDT's psychological needs in the prediction of psychological health and well-being and relatively few studies have examined their involvement in *physiological* functioning. Although some previous studies do suggest that these psychological needs are implicated in the regulation of individuals' physiological needs including, for example, the regulation of eating behavior (e.g., Bartholomew, Ntoumanis, & Thøgersen-Ntoumani, 2011; Verstuyf, Vansteenkiste, Soenens, Boone, & Mouratidis, 2013), examination of their relation with other physiological needs is lacking. In particular, no previous studies have investigated whether they play a role in individuals' sleep despite the fundamental role of sufficient and good quality sleep in optimal functioning (Strine & Chapman, 2015). Thus, to the best of our knowledge, the present dissertation is the first to address this issue by systematically examining the association between need-based experiences and diverse sleep outcomes throughout eight empirical studies.

Overall, the findings presented within this dissertation confirmed the existence of such associations by cumulatively demonstrating a relation between psychological need-based experiences and sleep-related outcomes, a finding that emerged at both the between- and within-person level in non-clinical and clinical samples. That is, findings not only demonstrated that individuals who experienced less satisfaction of their psychological needs for autonomy, competence, and relatedness reported worse sleep quality, but also indicated that on days that individuals experienced more need frustration they also reported poorer sleep quality than usual. The period-to-period (e.g., pre-exams, exams, post-exams) and day-to-day monitoring of individuals' sleep has higher ecological validity compared to the one-shot cross-sectional studies. Findings revealed considerable variation in individuals sleep across days, with between 14 to 32 percent of the variance situated at the person level (i.e., Chapter 7: Study 1), implying that the remaining 68 to 86 percent is situated at the day level (excluding error variance). Given these fluctuations in individuals' sleep, it is of utmost importance that research seeks to identify predictors of sleep at the daily level. Importantly, the present findings indicated that need-based experiences contribute to day to day fluctuations in individuals sleep, although the strength of observed association was somewhat dependent on the sleep outcome under investigation.

While we consistently found evidence for an association between need-based experiences and individuals' sleep quality in seven studies (i.e., Chapter 2 – 7), the findings regarding the relation with sleep quantity were more variable. With regard to sleep quantity, in the non-clinical samples we found evidence that those who were more need satisfied reported somewhat longer sleep duration (i.e., in Chapter 2) and that within-person fluctuations in need frustration co-varied with self-reported and objectively assessed sleep quantity (i.e., in Chapter 3 and Chapter 7). However, in the clinical populations an association between need-based experiences and sleep quantity only emerged in one of the three clinical samples and only indirectly. Specifically, among individuals with unexplained chronic fatigue (i.e., Chapter 5) differences between patients in need frustration were found to be related to variation between patients in subjective and objective indicators of sleep quantity via symptoms of stress and subsequent negative sleep-related cognitions. Hence, across all clinical groups (i.e., PLHIV, CFS and unexplained chronic fatigue patients), need-based experiences failed to *directly* relate to sleep quantity. Although these findings need to be replicated, this suggests that perhaps among clinical samples who suffer from sleep disturbances need-based experiences may only relate to quantitative sleep outcomes to the extent that they elicit sleep-interfering arousal processes, which then in turn may culminate in a real sleep deficit. Indeed, these results suggest that indicators which are more proximal to individuals' sleep, such as stress and negative sleep-related cognitions, may be more important and may need to be included in clinical populations in order to find effects on sleep quantity. Overall, this differentiated pattern of findings supports our heterogeneous approach to assessing sleep as it seemed that the association between need-based experiences and sleep quality was more robust across non-clinical and clinical samples than the relation with individuals' sleep quantity. In light of these findings, we caution against the creation of composite scores to operationalize sleep, which is commonly done with one of the key measures in the field, that is, the PSQI (Pittsburgh Sleep Quality Index; Buysse et al., 1989; e.g., Yeung, Ramirez, & Lu, 2017). If we had not broken the PSQI down into subcomponents, these more nuanced findings would not have emerged.

Apart from combining quantitative and qualitative indicators of sleep into a single measure, scholars also often include indicators of day-related functioning as a subcomponent of sleep (e.g., "During the past month, how much of a problem has it been for you to keep up enthusiasm to get things done?"). However, this practice blurs the conclusions that can be drawn because any observed effect of a given predictor could be completely due to its association with the day-related indicator, whereas the findings are interpreted in terms of carrying an effect on sleep outcomes. For this reason, in the present dissertation we opted to distinguish between qualitative, quantitative and day-related sleep indicators. While we recognize that day-related indictors of subjective energy are not necessarily indicative of individuals' sleep, they are closely related to the quality and quantity of one's sleep. Furthermore, their inclusion as a sleep-related outcome is consistent with the existing measures which are typically used to assess individuals' sleep (e.g., PSQI; Buysse et al., 1989). Finally, it is worth mentioning that in addition to treating the day-related indicators as a separate outcome, we also controlled for their shared variance with sleep outcomes in a number of studies (Chapter 2, Chapter 5, & Chapter 7: Study 2). This allowed for an even more conservative test of the need-sleep associations as any observed effects with sleep outcomes, when considered in isolation from the sleep measures, may be spurious, that is, disappear after controlling for the shared variance between the sleep and day indicators. Given that the contribution of needs to sleep outcomes even held within the integrative models which were tested, we can conclude with even greater confidence that the need-sleep associations are robust.

The decomposition of the composite score into day- and sleep-related indicators was especially fruitful in the present dissertation because the strongest and most systematic associations were found between need-based experiences and daytime indicators of individuals' energy and exhaustion, a finding that was obtained in seven studies (i.e., Chapter 2 - Chapter 7). These findings are in line with an extensive body of previous research which has similarly shown need satisfaction to relate to enhanced energy (e.g., Chen et al., 2015; Ryan & Deci, 2008) and need frustration to deplete energetic resources (e.g., Bartholomew et al., 2011). Importantly, the present findings extend previous research by demonstrating that the relation between need-based experiences and subjective energy even extends to clinical samples in which energy is severely compromised (i.e., patients with unexplained chronic fatigue: Chapter 5; and individuals with Chronic Fatigue Syndrome: Chapter 6).

2.1.2. The Universality of Basic Psychological Needs

As previously stated, SDT claims that the basic psychological needs for autonomy, competence, and relatedness are universal and that they therefore play a role in the health and well-being of all individuals. A host of previous studies have provided support for these claims. For example, previous research has shown that need satisfaction fosters well-being (e.g., life satisfaction and vitality) whereas need frustration is predictive of ill-being across individuals with different cultural backgrounds (e.g., Ahmad, Vansteenkiste, & Soenens, 2013; Chen et al., 2015). Furthermore, several studies have demonstrated need satisfaction to even relate to adaptive outcomes among individuals in autonomy restrictive contexts (Van der Kaap-Deeder et al., 2014; Van der Kaap-Deeder et al., 2017) and among those who state that they don't value these needs or that they have little desire for these needs to be met (Chen et al., 2015; Van Asshe, Van der Kaap-Deeder, Audenaert, De Schryver, & Vansteenkiste, 2017). Finally, the benefits of need satisfaction have also been shown to extend to several clinical populations including, for example, adolescents with severe emotional and behavioural problems (e.g., Savard, Joussemet, Pelletier, & Mageau, 2013).

The present findings add to this body of research by providing further evidence for SDT's universality claim among diverse non-clinical and clinical samples. Specifically, the present findings demonstrated that the association between need-based experiences and sleep quality not only applied to diverse non-clinical healthy samples of different ages (i.e., adolescents, emerging adults and adults) but also generalized to clinical samples in which sleep disturbances are highly prevalent (i.e., PLHIV, individuals with unexplained fatigue, and CFS patients). Furthermore, as noted earlier, the association between need-based experiences and indicators of subjective energy not only emerged among non-clinical samples (i.e., adolescents, emerging adults and adults) but also applied to two clinical samples in which energy is severely depleted (i.e., individuals with unexplained fatigue, and CFS patients). However, of note, the direct relation between need-based experiences and sleep quantity which was observed in the non-clinical samples (i.e., among adolescents, emerging adults, & adults), did not generalize to the clinical populations (i.e., PLHIV, CFS patients and individuals with unexplained chronic fatigue). As noted previously, this may be because other psychological factors, such as stress and negative pre-sleep cognitions which are more proximally related to individuals sleep are especially implicated in the shorter sleep quantity of individuals who suffer from more chronic sleep difficulties. Indeed, findings from Chapter 5 indicated that among individuals with unexplained chronic fatigue, need frustration from the past week related to more symptoms of stress and subsequent negative sleep-related cognitions, which then in turn, related to shorter subjective and objective sleep quantity.

Finally, the present findings also extended previous research in non-clinical populations which found need satisfaction to relate positively to indicators of well-being by demonstrating need satisfaction to relate to higher physical and mental health among people living with HIV, a patient group whose physical health is compromised (i.e., Chapter 4). Overall, these findings indicate that need-based experiences even play a role in the sleep, health and well-being of individuals who suffer from impoverished physical functioning. This is important because one might argue that in these clinical groups impoverished physical functioning may dominate individuals functioning so heavily that psychological factors make no difference to individuals' health and well-being. Indeed, Maslow's hierarchy of needs (Maslow, 1943) suggests that first level physiological needs have to be satisfied before other higher order psychological needs can enhance functioning. These results speak against this idea as it seems that even among individuals who suffer from sleep disturbances, depleted energetic resources, and compromised physical health, psychological needs still contribute to indicators of health and well-being

2.1.3. The Differential Role of Need Satisfaction and Need Frustration

While traditionally research within SDT has focused on the role of the satisfaction of basic psychological needs in promoting psychological growth and well-being, more recently this focus has begun to shift with an increasing number of studies uncovering the costs associated with the active frustration of basic psychological needs (Vansteenkiste & Ryan, 2013). Both dynamics deserve to be studied in their own right because a lack of need satisfaction does not necessarily imply that individuals' needs are actively frustrated. In fact, for need frustration to occur individuals' needs have to be more actively undermined. Furthermore, even when individuals experience low need frustration, this does not necessarily mean that they are flourishing. Rather, the enhancement of well-being requires the satisfaction of individuals' psychological needs. In light of these theoretical considerations, a recent wave of studies suggests that, relative to a lack of need satisfaction, need frustration is especially damaging and a more robust predictor of ill-being. For example, recent studies suggest that the frustration of psychological needs is uniquely predictive of exhaustion, depressive symptoms, anxiety and disordered eating (Bartholomew et al., 2011; Cordeiro, Paixão, Lens, Lacante, & Luyckx, 2016; Verstuyf, Vansteenkiste, Soenens, Boone, & Mouratidis, 2013) over and above a lack of need fulfillment.

The present dissertation further extended this rapidly growing body of work by examining the differential role of need satisfaction- and need frustration in the prediction of individuals' quality and quantity of sleep as well as their subjective energy. With regard to the sleep outcomes we hypothesized that need frustration would obstruct quality and quantity of sleep at night, whereas need satisfaction may be conducive to individuals' sleep. With respect to subjective energy, we expected need frustration to be especially predictive of negative indicators of energy (i.e., fatigue) and need satisfaction to be especially related to positive indicators of energy (i.e., vitality).

The unique role of need satisfaction- and frustration in the prediction of these outcomes was examined in four studies (Chapter 5 to Chapter 7). Each of these studies provided evidence for a unique association between need frustration and poorer sleep outcomes. Specifically, in Chapter 7 two diary studies among non-clinical adolescent samples indicated that daily need frustration was uniquely predictive of both poorer sleep quality and shorter self-reported and objectively assessed sleep quantity, over and above a lack of need satisfaction. Similar findings were obtained in two clinical samples with between-person differences in need frustration being uniquely related to poorer quality and shorter subjective and objective sleep quantity among individuals with unexplained chronic fatigue (i.e., in Chapter 5) and a diary study showing daily need frustration to be uniquely related to poorer daily sleep quality among CFS patients (i.e., in Chapter 6). With regard to subjective energy, we indeed found some evidence that need satisfaction was more strongly related to feelings of vitality (i.e., in Chapter 6 among CFS patients). However, findings regarding the differential role of need satisfaction- and frustration in the prediction of fatigue were more mixed. Specifically, in two studies both need satisfaction- and frustration contributed uniquely to fatigue, albeit in opposite ways, (i.e., Chapter 6 and Chapter 7: Study 1), whereas two other studies demonstrated need frustration to be uniquely predictive of fatigue (i.e., Chapter 5 and Chapter 7: Study 2).

Overall, these findings suggest that while need frustration plays a critical role in obstructing individuals sleep, it seems that for individuals to experience fatigue their needs may not necessarily need to be actively undermined, rather a lack of need satisfaction in itself may be draining. Interestingly, in these studies examining the differential role of need satisfaction- and frustration in the prediction of sleep outcomes, need frustration consistently related to poorer sleep outcomes, but need satisfaction did not seem to facilitate better sleep. With regard to sleep quantity in particular, this is perhaps because there is only a certain number of hours that an individual can sleep before they reach their limit. Hence, perhaps once individuals have slept a sufficient amount, need satisfaction cannot contribute to even higher sleep duration. Of course, this suggests that there may be a curvilinear relationship between need satisfaction and sleep quantity, an issue that could be explored in future research. However, this same explanation does not hold for sleep quality as presumably when it comes to the quality of individuals sleep, the sky is the limit and there is no critical threshold after which individuals do not benefit from even better sleep quality. Thus, it remains somewhat puzzling as to why need satisfaction does not appear to uniquely contribute to better sleep quality.

Given that the present dissertation provided some evidence for the distinct role of need frustration in predicting poorer quality and quantity of sleep over and above a lack of need fulfillment, it seems important that future research more systematically addresses the unique role of need satisfaction- and frustration in the prediction of sleep outcomes. Of note, although we examined the unique role of the three separate needs (i.e., for autonomy, competence, and relatedness) in two studies (ie., in Chapter 2 and Chapter 5), in general we did not for conceptual and methodological reasons. More specifically, we did not have any specific hypotheses regarding the differential role of autonomy, competence, and relatedness, in the prediction of the sleep-related outcomes, given that all three needs are presumed to play an equal role in optimal functioning and well-being. Furthermore, in some cases the high correlation between the three needs created issues of multicollinearity when examining their unique contributions. However, as shown in the appendix, at a correlational level all three needs largely yielded similar correlates with the sleep and day outcomes, which justified their combination into a composite score.

2.1.4. Future Directions

Although the present dissertation did systematically provide evidence for an association between need-based experiences and diverse sleep-related outcomes, there is still more research needed to shed light on (a) generalizability, (b) causality and (c) that adopts a multi-method approach.

Generalizability. While associations emerged between need-based experiences and sleep outcomes in diverse non-clinical and clinical groups, each of the samples were fairly homogenous (perhaps with exception of the samples used in Chapter 2 and Chapter 5). That is, across chapters a broad diversity of samples was included (in terms of age, educational background and clinical status), yet, within each of the separate chapters the participants sampled were fairly homogeneous. As a result, the present dissertation has only begun to shed light on the notion of generalizability. Future research could collect data in a single, more diverse sample, for example, by including individuals with more varied sociodemographic backgrounds. Doing so would allow scholars to directly test these variables as potential moderators of the need-sleep association (e.g., as part of a multi-group model).

Two types of samples in particular were underrepresented. First, although we did sample individuals across various age groups, there is still a need for more research to examine the need-sleep dynamic in lived, day to day processes among *non-clinical adult* samples. Second, although we demonstrated the need-sleep association to generalize to several clinical groups, in all of these samples sleep disturbances were a co-morbid complaint rather than the central pathology. Thus, it would be interesting to examine whether the observed associations also apply to individuals with primary insomnia which is not co-morbid with or caused by any underlying medical or psychiatric condition (American Psychiatric Association, 2013).

Furthermore, future research examining clinical populations would benefit from including matched non-clinical control groups. This would allow for a strict test of the differences in the need-sleep association between non-clinical and clinical samples. For example, this would allow for an examination of whether the observed associations are more pronounced in clinical samples in which sleep disturbances are highly prevalent. In addition, future research could contrast several clinical groups who suffer from sleep disturbances with one another using multiple-group analysis to examine whether clinical status serves as a moderator of the need-sleep association.

Causality. Although cross-sectional, longitudinal and diary methodology were used to examine the role of need-based experiences in predicting sleep, all of these methods produced findings which are correlational in nature. Unfortunately, these correlational designs precluded conclusions about the direction of effects. For this reason, future experimental research is needed to infer whether need frustration precedes rather than follows from poor sleep. For example, an experimental study could be conducted in which a need-frustrating, relative to a need-satisfying or neutral experience, is made salient before bedtime (see also Sheldon & Filak, 2008). In the experimental groups participants could be instructed to recall a need-related experience from the past week (i.e., either a need satisfying or frustrating experience), whereas in the control condition participants could simply be instructed to think about a neutral event. A number of factual questions (e.g., when did it take place, who was there, how did they feel and what role did they play) would then be asked and a manipulation check (e.g., Vansteenkiste et al., 2004) would be administered. In addition, sleep outcomes would be assessed both objectively (via actigraphy) and subjectively in the morning. ANOVA analyses could then be conducted to examine whether the reactivation of a need-frustrating, relative to a need-satisfying and neutral experience interfered with individuals sleep that night by, for example, eliciting more negative sleep-interfering thoughts.

Multi-method Approach. Finally, although we included an objective assessment of sleep in three of the eight studies we conducted, in the other five studies we only assessed sleep using self-reports which may have inflated some of the observed associations due to shared method variance. Thus, there is a need for future research to more systematically include objective assessments of sleep among both non-clinical and clinical samples. Ideally, any future studies would include a combination of self-reports and either wrist actigraphy or polysomnography to assess individuals sleep. While Polysomnography (PSG) is generally considered the “gold standard” for measuring sleep objectively because it not only assesses wake and sleep time, but also sleep architecture (i.e., the time spent in different sleep stages), PSG is carried out in a laboratory setting and is invasive, costly and inconvenient for assessing sleep for periods longer than one or two nights. In contrast, wrist actigraphy monitors an individual’s movement and allows for the differentiation of probable wake and sleep states. It is an unobtrusive device that can be worn at home in an individual’s natural environment over longer periods of time, and is therefore more ecologically valid.

Using both self-reported and objective measures to assess sleep would allow for an examination of the discrepancies between self-reported and objectively assessed sleep in both non-clinical and clinical populations. Indeed, previous research indicates that individuals with chronic sleep disturbances tend to overestimate nocturnal awakenings and underestimate total sleep time which may magnify the sleep problem, whereas good sleepers do the opposite (e.g., Fichten, Creti, Amsel, Bailes, & Libman, 2005). Future research could seek to identify psychological predictors which help to explain the size of these discrepancies. For example, given that mindful individuals likely have a heightened awareness of internal cues of bodily functioning, it may be that individuals higher in mindfulness are better at more accurately estimating their sleep quantity, whereas individuals lower in mindfulness may suffer more from sleep misperception.

2.2. Reflections on Explanatory Processes (Objective 3)

2.2.1. The Combined Role of Stress and Sleep-related Cognitions

Apart from demonstrating the direct contribution of need-based experiences in the prediction of sleep, the present research also uncovered evidence for the role of symptoms of stress and negative sleep-related cognitions as explanatory processes which account for the observed need-sleep association. Extending previous findings which found need frustrating experiences to play a role in stress reactivity (for an overview see Weinstein & Ryan, 2010), in three studies need frustration was found to contribute to higher symptoms of stress and subsequent sleep disturbances. Specifically, in two non-clinical samples (i.e., emerging adults: Chapter 3; adolescents: Chapter 7) fluctuations in participants' experiences of need frustration, either from week to week or from day to day, were found to co-vary with symptoms of stress, which in turn related to fluctuations in both quality and quantity of sleep and subjective energy. Although numerous previous studies have found stress to relate to poorer sleep (e.g., Galambos et al., 2009; Galambos, Vargas Lascano, Howard & Maggs, 2013; Lund, Reider, Whiting & Prichard, 2010) the present findings build on previous research by identifying specific psychological experiences which are likely to engender symptoms of stress and subsequent sleep disturbances. The identification of the frustration of the needs for autonomy, competence, and relatedness as three likely sources of stress is important because it is a first step in informing intervention efforts which seek to help reduce stress and subsequent sleep disturbances. That is, by identifying specific experiences, such as the satisfaction of the psychological needs for autonomy, competence, and relatedness, which can be targeted through time- and cost-effective interventions (e.g., Weinstein, Khabbaz, & Legate, 2016), symptoms of stress and subsequent poor sleep can possibly be avoided.

Whereas in Chapter 3 and Chapter 7 we found evidence for the explanatory role of stress, in Chapter 5 we found evidence for the intervening role of both stress and subsequent negative sleep-related cognitions in the need frustration-sleep relation. Importantly, while the stress measure assessed *daytime* symptoms of stress, the negative sleep-related cognitions were assessed in the *pre-sleep* period and were more proximal predictors of individuals' sleep. The finding that need frustration sparked a negative spiral of stress and negative sleep-related cognitions builds on previous research which indicated that need frustration is likely to engender more rumination (Van der Kaap-Deeder, Vansteenkiste, Van Petegem, Raes, & Soenens, 2016) by showing that need frustration may also contribute to more negative pre-sleep thoughts, including worrying about the consequences of not getting enough sleep, through (i.e., explained by) higher symptoms of stress. While need frustration related to evening fatigue through (i.e., explained by) symptoms of stress, need frustration related to the subjective and objective sleep outcomes through (i.e., explained by) the combined presence of both stress and negative sleep-related cognitions. Thus, the explanatory role of stress and negative-sleep related cognitions may be both unique and complementary. That is, while stress may especially explain the association between need frustration and fatigue, the combined presence of both stress and negative sleep-related cognitions may help to explain why need-frustrating experiences in particular relate to poorer sleep quality and shorter sleep quantity, especially among clinical samples at risk for poor sleep.

2.2.2. Future Directions

Somatic and Cognitive Arousal. It is important to note that the stress measure which we included in the present dissertation assessed the extent to which participants experienced symptoms of stress such as tension, arousal and difficultly relaxing (Lovibond & Lovibond, 2004) either during the day or during the past week. Thus, rather than assessing the degree to which certain situations or events were appraised as stressful (e.g., the perceived stress scale; Cohen, Kamark & Mermelstein, 1983), our stress measure was likely more indicative of the somatic arousal which follows from stressful experiences. Although it has previously been proposed that psychosocial stressors elicit pre-sleep somatic and negative sleep-related thoughts, which then concurrently interfere with sleep at night (e.g., Riemann et al. 2010), in Chapter 5 we found evidence for symptoms of stress (i.e., somatic arousal) preceding negative sleep-related thoughts which then in turn related to poorer sleep outcomes during a stay at a sleep laboratory. This slightly different sequencing of the variables is likely due to the timing of our measurement which assessed symptoms of stress during the past day or week (rather than in the pre-sleep period), which of course preceded participants' negative sleep-related thoughts during the stay at the sleep laboratory. It seems important for future research to more systematically examine the explanatory processes which account for the need-sleep relation by not only examining perceived stress during the day but by also more systematically assessing cognitive and somatic arousal processes in the pre-sleep period (e.g., Pre-sleep arousal scale; Nicassio, Mendlowitz, Fussell, & Petras, 1985) in both non-clinical and clinical samples. Furthermore, evidence for the intervening role of stress and negative sleep-related cognitions was only obtained in one clinical sample. Future research is needed to examine whether these same mechanisms also play an explanatory role in other clinical groups as well as in non-clinical groups. In addition, future studies could assess negative thoughts more broadly rather than focusing solely on sleep-related negative thoughts. Perhaps, more general negative thoughts play a role in the poor sleep of healthy individuals, whereas sleep-related negative thoughts may be especially involved in the maintenance of chronic sleep disturbances. Put differently, the specific manifestation of negative thoughts may be sample-bound, with somatic arousal, stemming from need frustration, giving rise to either more general or sleep-related negative thoughts depending on the sample under investigation.

Beyond Self-reports. An important limitation of the current research is that the explanatory processes which were examined (i.e., symptoms of stress and negative sleep-related cognitions) were assessed using self-reports which again may have inflated the observed associations due to shared method variance. Future studies could try to overcome this problem by using more objective methods to assess these explanatory mechanisms. For example, salivary samples could be collected to measure levels of the stress hormone cortisol (e.g., Sladek & Doane, 2015). In addition, pre-sleep thoughts could also be measured objectively by asking participants to place a tape recorder on their bedside table and instructing them to say aloud whatever is going through their mind when they have difficulty falling asleep (e.g., Wicklow & Espie, 2000).

Sleep Hygiene. Finally, in the present dissertation we focused exclusively on the explanatory role of arousal processes (i.e., symptoms of stress and negative sleep-related thoughts) in the relation between need-based experiences and sleep. However, another possible explanatory pathway which was not examined in the present dissertation is that need frustration may interfere with the optimal regulation of sleep. Indeed, previous research has shown that certain self-regulatory behaviors, referred to as sleep hygiene behaviors, play a role in the quality and quantity of individuals sleep (e.g., Gellis & Lichstein, 2009). Good sleep hygiene behaviors include maintaining a regular sleep schedule, disengaging form arousing activities close to bedtime and avoiding feeling worried whilst falling asleep (Brown, Buboltz, & Soper, 2002). A large proportion of the general public report difficulties in maintaining a regular sleep schedule (e.g., Kroese, Evers, & Adriaanse, & De Ridder, 2016), suggesting that for many individuals persisting in healthy sleep hygiene behaviors is likely a challenging task that requires self-control and energy. Given that findings from both the present dissertation and previous research indicate that need frustration is likely to deplete energetic resources (e.g., Bartholomew et al., 2011), this raises the possibility that need frustration may interfere with sleep hygiene behaviors through depleting the energy needed to enact these behaviors. Alternatively, poor sleep hygiene behaviors may also arise directly from need frustration (i.e., without being accounted for by reduced energy) as a means to cope with experienced need frustration during the day. Indeed, within SDT it has been proposed that following need frustration people will try to replenish their needs, often in maladaptive ways using need-substitutes that only produce short-term benefits. For example, after a day of feeling particularly socially excluded an adolescent may spend excessive time on social media until late at night in an attempt to restore their need for relatedness, rather than going to bed on time, thereby disrupting their sleep. Thus, apart from need frustration impeding restful sleep by eliciting emotional arousal, another possibility is that need frustration may also obstruct sleep at night by interfering with sleep hygiene behaviors. Future research should assess a broader range of possible intervening mechanisms, including sleep hygiene behaviors, to obtain a better understanding of the different explanatory processes involved in the need-sleep association.

2.3. Reflections on the Reciprocal and Causal Relation between Sleep and Psychological Functioning (Objective 4)

2.3.1. The Interface between Psychological and Physiological Needs

While theoretical frameworks like SDT propose that all human beings have a set of inherent fundamental basic psychological needs, all humans of course also possess basic physiological needs, the fulfillment of which is equally essential for health and well-being. While psychologists have identified critical psychological needs (autonomy, competence, relatedness) for individuals' well-being, the physiological need for sleep has received extensive attention in the field of sleep medicine. Ideally, the fulfillment of both psychological needs and physiological needs would be considered together to achieve a richer and more comprehensive understanding of individuals' well-being and health, as an exclusive focus on either psychological or physical needs is incomplete. SDT has been rather one sided in this respect by exclusively focusing on the role of psychological factors in promoting health and well-being. Indeed, there is an increasing recognition that psychological and physical health affect each other reciprocally and need to be considered together to understand individuals' full functioning (Uchino et al., 1996). However, despite this recognition there is still a paucity of work examining the reciprocal interplay between both types of needs.

The present dissertation took some first steps in addressing this issue of reciprocity by systematically demonstrating that need-based experiences were not just predictive of but were also predicted by sleep at night. In Chapter 6 and Chapter 7, results from three diary studies consistently demonstrated among both non-clinical (i.e., adolescents) and clinical (i.e., Chronic Fatigue Syndrome patients) samples, that after nights of poorer quality sleep participants reported experiencing more need frustration the next day. In contrast, an association between shorter daily sleep quantity and more next day need frustration only emerged in one of the three diary studies (i.e., Study 1: adolescents). The finding that sleep quality rather than sleep quantity was a more robust predictor of next day functioning is interesting because it is somewhat counterintuitive. Indeed, people often attribute poor psychological functioning throughout the day to shorter daily sleep duration than usual, but these findings suggest poorer sleep quality than usual is a more critical predictor of individuals daily psychological functioning. Furthermore, these findings further support the separation of sleep into qualitative and quantitative indicators given that sleep quality, rather than sleep quantity, especially contributed to individuals daily functioning.

Rather than examining the predictive role of naturally occurring day to day variation in quality and quantity of sleep, in Chapter 8 we examined the effects of three days of experimentally induced sleep debt (i.e., less than 5 hours sleep per night) on need-based functioning. Findings revealed that it took three days of partial sleep deprivation before participants reported significantly decreased need satisfaction relative to their baseline and relative to the control group. Thus, it seems that for sleep debt to have an effect of individuals need-based functioning it may need to be deprived below a certain level (i.e., less than 5 hours of sleep a night) and accumulated across days. Notably, for participants to experience their psychological needs as being frustrated rather than merely dissatisfied, the sleep deprivation may need to be more intensive (e.g., less than 4 hours of sleep) and prolonged across more days, an issue that could be explored in future work. The observed effects of partial sleep deprivation on need satisfaction also shed light on the non-significant association in the diary studies. Although participants' sleep quantity may deviate from their own average on some days, the question is whether the deprivation goes beyond a certain critical, absolute threshold, as was the case in the experimental study. Perhaps, the deviations in the diary studies were rather mild and participants' sleep quantity still stayed above the critical threshold needed for intra-personal deviations to relate to participants' subsequent need-based experiences.

Overall, the present findings provide preliminary evidence that basic psychological need experiences and the physiological need for sleep do indeed reciprocally relate to one another. These findings suggest that the deprivation of the physiological need for sleep may constitute a threat for psychological need satisfaction, whereas need frustration is likely to interfere with the fulfillment of the physiological need for sleep. Given this evidence suggesting that psychological needs and sleep are reciprocally related, and given that both psychological needs and sleep are implicated in individuals' well-being (e.g., Deci & Ryan, 2000; Strine & Chapman, 2015), another interesting question that arises is whether they both independently or synergistically contribute to individuals well-being. Interestingly, in the cross-sectional study conducted among people living with HIV (i.e., Chapter 4) we found that when need satisfaction and sleep quality were entered simultaneously in the prediction of indicators of well-being both need satisfaction and sleep quality yielded a unique association with mental health. This finding provided some preliminary evidence that both need satisfaction and sleep quality play a distinct contributory role to individuals' psychological well-being.

2.3.2. Future Directions:

Generalizability. In light of these findings it seems important for future research to continue to examine the reciprocal relation between psychological needs and individual's quality and quantity of sleep. The samples used in the diary studies and experimental study which examined these reciprocal relations were fairly homogenous and objective measures of sleep were not systematically included. Thus, future research should seek to further examine these reciprocal day to day associations among more heterogeneous samples using both self-report and objective assessments of sleep.

Role of Psychological Needs and Sleep in Well-being. Given that both psychological needs and sleep have previously been shown to play a fundamental role in individual's well-being, it seems important for future research to further examine whether they contribute independently or interactively to individuals well-being. These future studies could directly test the assumptions of Maslow's proposed hierarchy of needs (Maslow, 1943), which states that the physiological need for sleep is a first level need that must be satisfied before other higher level psychological needs can contribute to individuals' functioning. In other words, Maslow's hierarchical needs model seems to suggest that the physiological need for sleep is a more fundamental need than psychological needs which are situated higher up in the hierarchy. Thus, if need satisfaction does yield an independent relation with well-being over and above the physiological need for sleep, this would directly challenge Maslow's hierarchically organized needs model.

Sleep Fragmentation. In addition, given that the results from the three diary studies indicated that day to day variation in sleep quality, rather than sleep quantity, was more consistently predictive of next day need experiences, it would be interesting for future experimental research to examine whether manipulating the quality, rather than the quantity, of individuals sleep has a more pronounced effect on need-based functioning. Much like the experimental study we conducted in Chapter 8, an experimental study could be conducted in which participants sleep continuity is interrupted throughout the night. Similarly, a 4 day within-person design could be used involving a baseline assessment (i.e., on Day 1) followed by three consecutive nights in which participants sleep would be interrupted at regular intervals (e.g., Finan, Quartana, & Smith, 2015). A control group would also be included in which participants would be instructed to sleep as usual for the 4 day period. Participants sleep could be monitored via wrist actigraphy and their need-based functioning could be assessed through diary reports. Repeated measure ANOVAS could then be used to examine whether the experimentally induced variation in sleep continuity between the two conditions would cause variation in need-based experiences.

2.4. Reflections on the Role of Mindfulness (Objective 5)

2.4. 1. The Salutary Role of Mindfulness

Although previous research has demonstrated mindfulness, which is conceptualized as an open and receptive awareness to present moment experiences (Brown & Ryan, 2003), to relate to better sleep outcomes (e.g., Howell et al., 2010; Howell et al., 2008), little is known about the mechanisms which account for this salutary relation. Consistent with previous research, the findings from Chapter 2 and Chapter 4 similarly found higher dispositional mindfulness to relate to better sleep quality among both non-clinical (i.e., healthy adults) and clinical (i.e., people living with HIV) samples. More importantly, in both samples higher need satisfaction completely accounted for (i.e., explained) the relation between mindfulness and better sleep quality. Replicating a previous study which found mindfulness to relate to higher need satisfaction (e.g., Brown & Ryan, 2003), these findings suggest that individuals higher in trait mindfulness experience more psychological need satisfaction within their lives, which then in turn relates to better quality sleep. There are several possible reasons why individuals who are more mindful experience more satisfaction. First, because the heightened awareness characteristic of mindfulness likely facilitates individuals to more wholeheartedly engage in daily activities so that more need satisfaction is derived. Second, mindful individuals are likely to be more in touch with their true interests and values, which may result in them proactively selecting and engaging in activities which are inherently need satisfying as well as being more responsive to opportunities for need satisfaction throughout the day. Third, when confronted with need frustrating situations, mindful individuals are less likely to respond in autonomic maladaptive ways, and are likely to first reflect and ensure that their response is congruent with their values, thereby minimizing the resulting need frustration. Presumably, higher need satisfaction in turn elicits more positive emotions and less stress and negative cognitive arousal, which is conducive to relaxation and restful sleep at night. In Chapter 8 we also found evidence that three days of sleep deprivation impaired individuals' capacity to be mindful which then in turn related to decreased need satisfaction. Overall, these findings suggest that mindfulness may not only predict sleep at night via need satisfaction but that sleep restriction at night may also contribute to reduced need satisfaction via impaired mindfulness.

The finding that need satisfaction completely accounted for the association between mindfulness and sleep quality is interesting because based on previous theorizing regarding mindfulness and sleep (e.g., Lundh 2005; Ong, Ulmer, & Manber 2012), one might expect mindfulness to continue to yield a direct association with sleep quality because it would promote acceptance and a more observant stance to sleep-interfering arousal processes. These findings may be specific to our cross-sectional designs which assessed mindfulness, need satisfaction and sleep during the past month and perhaps other designs (e.g., diary designs) would yield different findings.

With regard to daytime functioning, findings from Chapter 2 revealed that higher need satisfaction only partially accounted for the relation between mindfulness and less daytime dysfunction (as indexed by lower fatigue and higher vitality). Thus, mindfulness continued to yield a direct negative relation with daytime dysfunction. Similarly, in Chapter 8 findings indicated that following three days of sleep deprivation impaired mindfulness related directly to increased fatigue (i.e., without being accounted for by reduced need satisfaction). Together, these findings indicate that higher mindfulness relates to more subjective energy and that, conversely, low mindfulness leaves individuals fatigued. This is presumably because when mindful, individuals are likely to more wholeheartedly engage in daily activities so that more energy is derived from these activities, whereas not acting mindfully may leave individuals more susceptible to automatic and habitual negative thought patterns such as worry and rumination. These negative thought patterns may require considerable energy to refocus attention onto ongoing activities which by itself may drain energetic resources.

2.4.2. Future directions:

Moderating Role of Mindfulness. Overall, throughout the present dissertation we found some evidence that (a) higher trait mindfulness relates to better sleep quality via need satisfaction (i.e., in Chapter 2 and Chapter 4) and that (b) sleep deprivation impairs state mindfulness which in turn relates to reduced need satisfaction (i.e., Chapter 8). However, another possibility which was not examined in the present dissertation is that the need frustration – poor sleep relation (and vice versa) may be attenuated among individuals high in mindfulness (i.e., moderation). This is because rather than responding in a habitual dysfunctional manner to need frustrating experiences, individuals who are high in mindfulness are likely to respond more adaptively (e.g., Brown, Weinstein, & Creswell 2012; Weinstein, Brown & Ryan, 2009), thereby eliciting less stress and fewer negative pre-sleep cognitions. Future diary studies could not only examine whether trait mindfulness, assessed at baseline, would contribute to better subjective and objective sleep across days (i.e., main effect) but could also investigate whether the day-to-day relation between need frustration and poor sleep and vice versa would be weaker among more mindful individuals (i.e., moderation). Indeed, mindfulness may also play a protective role in the relation between poor sleep and need frustration, as the enhanced awareness typical of mindful individuals may result in more acceptance to poor sleep, perhaps eliciting less daytime dysfunction. As a result, individuals higher in dispositional mindfulness may be more capable of effectively selecting and engaging in need satisfying activities despite having slept poorly (qualitatively speaking) or insufficiently (quantitatively speaking).

In addition, the possible moderating role of mindfulness could also be assessed in the experimental studies which were previously proposed to examine the impact of need-based experiences on sleep at night and vice versa. For example, the first experimental study that was proposed to examine the effect of making a need frustrating relative to a need satisfying or neutral experience salient before bedtime, could also examine whether the hypothesized detrimental effect of recalling a need frustrating experience on sleep is weaker among individuals higher in trait mindfulness (as assessed at baseline). Similarly, the second experimental study we proposed to examine the effect of disrupting sleep continuity on individuals need-based functioning could also examine whether the hypothesized increase in need frustration and fatigue in the experimental group is attenuated among individuals higher in trait mindfulness (as assessed at baseline).

Mindfulness Training. A future intervention study could also examine whether participation in a self-administered, cost- and time-effective mindfulness training (e.g., Hülsheger, Feinholdt, & Nübold, 2015) protects individuals against the occurrence of, as well as the detrimental effects of both need frustration and sleep debt. For example, participants could be randomly assigned to either (a) an experimental condition, in which participants would independently engage in brief (15-min) guided audio mindfulness exercises twice a day for seven consecutive days (Hülsheger et al., 2015), or (b) a structurally equivalent active control condition, in which participants would independently engage in brief (15-min) guided audio relaxation exercises on a daily basis for seven consecutive days. Indeed, mindfulness and relaxation are dissociable and the former has demonstrated stronger effects in stress-related and other mental health interventions (e.g., Ditto, Eclache, & Goldman, 2006; Jain et al., 2007). Participants' need-based experiences, subjective energy, perceived stress, pre-sleep cognitions, and sleep outcomes could be assessed daily via evening and morning reports. Latent growth curve modelling could be used to examine whether the trajectory of participants' need-based experiences and sleep differs between experimental conditions (i.e., main effect), such that participants in the intervention group report better sleep outcomes and higher need satisfaction (see Mouratidis, Vansteenkiste, Sideridis, & Lens, 2011). The moderating role of mindfulness could be further examined in this study by examining whether (a) the association between daily need frustration and daily stress, pre-sleep cognitions and sleep is attenuated among individuals in the intervention group as well as whether (b) the reciprocal association between daily poor sleep and daily need frustration is weaker among individuals in the intervention group.

Finally, given that the results of the present dissertation suggest that mindfulness relates to better sleep outcomes through need satisfaction, these findings indicate that need satisfaction may represent an important mechanism of change in mindfulness-based interventions. Indeed, one way through which mindfulness-based interventions yield their positive effects on individuals sleep may be by enhancing participants' need satisfaction. Thus, any future mindfulness-based intervention studies could also systematically assess whether need satisfaction does indeed represent an important underlying mechanism of change.

3. Clinical Implications of the Findings

3.1. Current Clinical Approach

In order to understand the implications of our findings for clinical practice it is necessary to first briefly review the predominant approaches which are currently used to treat chronic sleep disturbance. Although medication is the most common form of treatment administered to people with acute sleeping problems (Krystal, 2009), psychological therapies are recommended for the treatment of chronic sleep disturbances (Qaseem, Kansagara, Forceia, Cooke, & Denberg, 2016). Most psychological treatments typically involve targeting the behavioral habits and dysfunctional cognitive processes that maintain poor sleep. The behavioral interventions with the most evidence-based support are stimulus control therapy, progressive muscle relaxation (PMR), and sleep restriction therapy (Taylor & Roane, 2010). Stimulus control therapy is based on the idea that the bedroom is often used for things other than sleep (e.g., watching TV or working in bed) and that because of this the bed or bedroom often loses its strength as a stimulus for sleep (Bootzin, 1972). Treatment involves re-establishing a healthy sleep routine (e.g., only using the bed for sleep or sex, removing any electronics form the bedroom, only going to bed when sleepy, etc.) in order to re-associate the bed/bedroom with sleep (Morin, 2006). Other behavioral techniques such as progressive muscle relaxation involve tensing different muscle groups to reduce somatic tension, whereas sleep restriction therapy involves limiting the total time spent in bed with the aim of increasing sleep efficiency (Spielman, Saskin, & Thorpy, 1987). The most widely used and recommended psychological treatment for chronic sleep disturbance is cognitive behavioral therapy for insomnia (CBT-I; Qaseem et al., 2016). CBT-I involves several behavioral components including techniques such as stimulus control, progressive muscle relaxation, sleep restriction, and sleep hygiene education as well as a cognitive component which involves cognitive restructuring. Cognitive restructuring addresses maladaptive thoughts which interfere with sleep, including dysfunctional beliefs and worries about lack of sleep, by challenging them and replacing them with alternative more adaptive thoughts (Taylor & Roane, 2010). More recently a so called “third wave” of CBT therapies have been introduced which focus less on controlling and changing maladaptive thoughts and more on reacting to thoughts in new ways through, for example, acceptance and mindfulness meditation. Mindfulness-based therapy for insomnia (MBTI) is one of these newer approaches which aims to help individuals change their relationship with their thoughts and improve sleep through a combination of behavioral techniques and meditation exercises (Ong, Shapiro, & Manber, 2008).

3.2. Clinical Approach Grounded in SDT and the Present Dissertation.

Overall, these current therapeutic interventions seek to improve individuals' sleep by focusing on their dysfunctional behavior and cognitions, the latter of which is targeted by attempts to either change the content of individuals' thoughts or the individual's relationship with their thoughts. However, the results of the present dissertation indicate that it is also important to identify and examine the deeper issues which underlie these sleep-interfering processes. In particular, the present findings highlight the importance of looking at the sources of individuals stress and dysfunctional cognitions and suggest that experiences of the frustration of individuals' need for autonomy, competence, and relatedness are likely to be at the root of these maladaptive arousal processes. If psychological interventions only seek to help individuals either change or cope with negative sleep-interfering arousal processes (i.e., those that are both cognitive and somatic in nature), then they may fail to address the fundamental issues that elicit these processes in the first place which should also be given equal importance. The present findings suggest that in addition to helping individuals' identify, change, and cope with sleep-interfering processes existing interventions should also incorporate a focus on individuals' basic psychological needs. For example, therapeutic interventions could also help people to identify ways to achieve more need satisfaction within their lives, as well as help them to find ways to avoid or cope better with need frustrating experiences when they arise. For example, healthcare professionals could work with their clients to identify activities which they find pleasurable and which they may feel good at as well as help them to achieve more deep and meaningful connections with those that are important to them. In line with this suggestion a recent one week intervention study among Syrian refuges which focused on helping participants to identify and engage in daily need satisfying activities demonstrated that participants reported reduced need frustration and fewer symptoms of stress following the intervention (Weinstein et al., 2016). This finding is encouraging given that our findings suggest that if a need supportive intervention reduces need frustration and stress, it is also likely to reduce any subsequent sleep disturbances.

In addition to engaging in more need satisfying activities it would also be important to help individuals to identify, recognize and possibly reduce sources of need frustration within their lives as well as regulate their emotional reactivity to these experiences when they do arise, as they inevitably will. This may involve making important life changes like, for example, ending a close relationship in which one is often made to feel worthless or unvalued. Naturally, it may not always be easy for people to remove themselves from need-thwarting contexts (e.g., from an abusive relationship or a controlling work environment), so it would also be important to help individuals to develop capacities for resilience to help them cope with as well as minimize their emotional arousal when they are faced with difficult situations. As discussed previously, mindfulness may be important in this respect as it may help individuals to respond more adaptively to these situations rather than reacting in habitual dysfunctional ways which would likely just serve to perpetuate the resulting need frustration and emotional arousal. Of course, findings from the present dissertation indicate that mindfulness is also likely to play an important role in promoting individuals' need satisfaction presumably because it helps people to wholeheartedly and proactively engage in and select need satisfying activities as well as to be more responsive to opportunities for need satisfaction in their daily lives.

Importantly, in any therapeutic intervention seeking to incorporate a focus on individuals' basic psychological needs it would not just be important to directly help individuals to achieve more need satisfaction within their own lives. It would also be equally important for healthcare professionals to foster need satisfaction within the therapeutic relationship (e.g., Van der Kaap-Deeder et al., 2014). Indeed, clinicians are likely to differ in the degree to which they are supportive of their clients' basic psychological needs. In other words, irrespective of the treatment being administered (e.g., CBT-I or MBTI), clinicians may differ in the extent to which they adopt a participative versus prescriptive approach or a more guiding versus a pressuring therapeutic style. From an SDT point of view the clinicians support of clients' basic psychological needs represents a critical factor common to all therapies that should lead to more beneficial outcomes irrespective of the particular intervention which is being delivered (Dwyer, Hornsey, Smith, Oei, Dingle, 2011; Ryan, Lynch, Vansteenkiste & Deci, 2011). Clients' need fulfillment could be promoted by responding in a warm and empathic manner (relatedness satisfaction), by providing individuals with a meaningful rationale for any home assignments and giving them choice wherever possible (autonomy satisfaction), as well as by providing structure within the therapy sessions and ensuring that any home assignments or agreements made are manageable for the client (competence satisfaction).

3.3. Need Frustration as a Transdiagnostic Risk Factor

Need frustration has previously been proposed to be a risk factor for a broad variety of psychopathologies (Ryan, Deci, & Vansteenkiste, 2016). In particular, a number of previous studies have implicated need frustration in depressive symptomatology, with various studies among healthy adults (Unanue, Dittmar, Vignoles, & Vansteenkiste, 2014) and athletes (Bartholomew et al., 2011) showing need frustration to be predictive of depressive symptoms. The present dissertation builds on previous findings by demonstrating need frustration to also be involved in sleep disturbance. Given that sleep disturbance and depressive symptoms are highly co-morbid with one another and often co-occur together (e.g., Staner et al., 2010), this raises the possibility that need frustration may be a transdiagnostic risk factor that helps to explain the high comorbidity between both types of symptomatologies. To formally test whether need frustration does indeed account for the co-occurrence between sleep disturbance and depressive symptoms, future research could examine whether the association between these two types of symptomatologies decreases when modeling need frustration as their common predictor (e.g., Boone, Campbell, Vansteenkiste, & Soenens, 2017; Nolen-Hoeksema & Watkins, 2011). The identification of transdiagnostic risk factors is very relevant to clinical practice, as it suggests that rather than having treatments which target different symptomatologies, treatment for different symptomatologies could target one common underlying factor (e.g., need frustration).

Although a transdiagnostic risk factor typically refers to a factor which explains the comorbidity between different types of symptomatologies (e.g., Boone, Campbell, Vansteenkiste, & Soenens, 2017), it could also be interpreted in a different way. That is, it could also be used to refer to a risk factor (i.e., need frustration) which predicts a specific symptomatology (i.e., sleep disturbances) across different diagnostic groups. Indeed, the results of the present dissertation indicated that need frustration was predictive of sleep disturbance in three different clinical groups each of which differed somewhat in their central pathology. Although more research is needed to replicate these findings in more diverse clinical populations, these findings imply that need frustration may be transdiagnostic risk factor that predicts sleep disturbance across different diagnostic groups. This possibility could be formally tested by contrasting several clinical groups with one another and examining whether clinical status moderates the relation between need frustration, stress, negative pre-sleep cognitions and sleep disturbance. This would allow for a stricter test of whether need frustration is a common factor underlying sleep disturbance in different clinical groups. If this is the case, the implication would be that irrespective of the clinical group for which an intervention targeted at reducing sleep disturbances is intended, it would be important for the intervention to focus on need-based experiences as they represent a risk factor for sleep disturbance across different diagnostic entities. Of course, consistent with the notion of equifinality, in each clinical group or indeed in each individual, the different contextual or personal characteristics which elicit need frustration are likely to vary greatly. For example, self-critical perfectionism is especially implicated in Chronic Fatigue Syndrome (e.g., Kempke, Luyten, Mayes, Van Houdenhove, Claes, 2015) and is likely to engender need frustration (Boone, Vansteenkiste, Van der Kaap-Deeder, Soenens, & Verstuyf, 2014), whereas people living with HIV (PLIV) often experience stigma (Peltzer, 2012) which may be a central source of need frustration. Thus, it would still be important for each intervention to be tailored to the specific clinical group or individual in question.

4. General Conclusion

The present dissertation was the first to systematically examine the association between the satisfaction and frustration of the basic psychological needs for autonomy, competence, and relatedness, and diverse sleep outcomes. In eight studies, the present findings cumulatively demonstrated a relationship between need-based experiences and self-reported and objective indicators of sleep at both the between- and within-person level in non-clinical and clinical samples. In addition, the present findings yielded evidence for the critical explanatory role of stress and negative sleep-related cognitions in the observed need-sleep association. Furthermore, need-based experiences were found to not only be predictive of but to also be predicted by quality and quantity of sleep at night, indicating that both are reciprocally related to one another. Indeed, it seems that need frustration is not only likely to precede poor sleep, but that poor sleep is likely to give rise to more need frustrating experiences, thereby trapping individuals in a negative vicious cycle. Finally, the findings also indicate that mindfulness is likely to promote need satisfaction which in turn may facilitate better sleep outcomes. Overall, these findings imply that healthcare professionals seeking to help individuals to improve their sleep should consider incorporating a focus on mindfulness and basic psychological needs within their therapeutic approach.

5. References

Ahmad I., Vansteenkiste M., Soenens B. (2013). The relations of Arab Jordanian adolescents' perceived maternal parenting to teacher-rated adjustment and problems: The intervening role of perceived need satisfaction. *Developmental Psychology*, *49*, 177–183.

Anderson, C., & Horne, J. A. (2006). Sleepiness enhances distraction during a monotonous task. *Sleep, 29*, 573-576.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Publishing.

Bartholomew, K. J., Ntoumanis, N., Ryan, R. M., & Thøgersen-Ntoumani, C. (2011). Psychological need thwarting in the sport context: Assessing the darker side of athletic experience. *Journal of Sport & Exercise Psychology, 33*, 75-102.

Boone, L., Campbell, R., Vansteenkiste, M., & Soenens, B. (under revision). Psychological need frustration as a transdiagnostic process in associations of self-critical perfectionism with depressive symptoms and eating pathology. *Manuscript under revision for Journal of Clinical Psychology.*

Boone, L., Vansteenkiste, M., van der Kaap-Deeder, J., Soenens, B., & Verstuyf, J. (2014). Self-critical perfectionism and binge eating symptoms: A longitudinal test of the intervening role of psychological need frustration. *Journal of Counseling Psychology, 61,* 363-73.

Bootzin, R.R. (1972). A stimulus control treatment for insomnia. *American Psychological Association 80th Annual Convention Proceedings, 7*, 395–396.

Brown, F., Buboltz, W.C., & Soper, B. (2002). Relationship of sleep hygiene awareness, sleep hygiene practices, and sleep quality in university students. Behavioral Medicine, 28, 33-38

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology*, *84*, 822–848. doi: 10.1037/0022-3514.84.4.822.

Brown, K. W., Weinstein, N., & Creswell, J. D. (2012). Trait mindfulness modulates neuroendocrine and affective responses to social evaluative threat. *Psychoneuroendocrinology, 37,* 2037-2041.

Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R. & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index – a new instrument for psychiatric practice and research. *Psychiatry Research, 28,* 193-213.

Chen, B., Vansteenkiste, M., Beyers, W., Boone, L., Deci, E. L., Duriez, B. Lens, W., Matos, L., Mouratidis, A., Ryan, R. M., Sheldon, K. M., Soenens, B., Van Petegem, S., & Van der Kaap-Deeder, J., Verstuyf, J (2015). Basic psychological need satisfaction, need frustration, and need strength across four cultures. *Motivation and Emotion, 39,* 216-236.

Cohen, S., Kamark, T., & Mermelstein, R. (1983). A global measure of perceived stress. *Journal of Health and Social Behavior, 24,* 385 – 96.

Cordeiro, P., Paixao, P., Lens, W., Lacante, M., & Luyckx, K (2016). The portuguese validation of the basic psychological need satisfaction and frustration scale: Concurrent and longitudinal relations to well-being and ill-being. *Psychologica Belgica, 56(3),* 193-209.

Deci, E. L. & Ryan, R. M. (2000). The ‘what’ and ‘why’ of goal pursuits: Human needs and the self determination of behavior. *Psychological Inquiry*, *11*, 227-268.

Ditto, B., Eclache, M., & Goldman, N. (2006). Short-term autonomic and cardiovascular effects of mindfulness body scan meditation. *Annals of Behavioral Medicine, 32,* 227-234.

Dwyer, L. A., Hornsey, M. J., Smith, L. G., Oei, T. P. S., Dingle, G. A. (2011). Participants’ autonomy in cognitive-behavioral group therapy: An integration of self-determination and cognitive-behavioral theories. *Journal of Social and Clinical Psychology, 30*, 24-46.

Espie, C.A., Broomfield, N.M., MacMahon, K.M., Macphee, L.M., Taylor, L.M. (2006). The attention-intention-effort pathway in the development of psychophysiologic insomnia: a theoretical review. *Sleep Medicine Reviews*, 10 (*4*), 215-243.

Fichten, S. C., Creti, L., Amsel, R., Bailes, S., & Libman, E. (2005). Time estimation in good and poor sleepers, *Journal of Behavioral Medicine, 28 (6),* 537-553.

Fichten, C.S., Libman, E., Creti, L., Amsel, R., Tagalakis, V., & Brender, W. (1998). Thoughts during awake times in older good and poorer sleepers – The self-statement test: 60+. *Cognitive Therapy and Research, 22(1),* 1-20.

Finan, P. H., Quartana, P.J., & Smith, M.T. (2015). The effects of sleep continuity disruption on positive mood and sleep architecture in healthy adults. *Sleep,38,* 1735-1742.

Fuligni, A. J., & Hardway, C. (2006). Daily variation in adolescents' sleep, activities, and psychological well-being. *Journal of Research on Adolescence, 16,* 353 – 377.

Galambos, N. L., Dalton, A. L., & Maggs, J. L. (2009). Losing sleep over it: Daily variation in sleep quantity and quality in Canadian students' first semester of university. *Journal of Research on Adolescence, 19,* 741-761.

Galambos, N.L., Vargas Lascano, D.I., Howard, A.L., Maggs, J.L. (2013). Who sleeps best? Longitudinal patterns and covariates of change in sleep quantity, quality, and timing across four university years. *Behavioral Sleep Medicine, 11,* 8-22. doi: 10.1080/15402002.2011.596234

Gellis, L.A., & Lichstein, K.L. (2009). Sleep hygiene practices of good and poor sleepers in the United States: an internet-based study. *Behavior Therapy, 40,* 1-9.

Harvey, A.G. (2002). A cognitive model of insomnia. *Behavior Research and Therapy*, *40*, 8, 869-893.

Howell, A. J., Digdon, N. L., & Buro, K. (2010). Mindfulness predicts sleep-related self-regulation and well-being. *Personality and Individual Differences*, *48,* 419-424.

Howell, A. J., Digdon, N. L., Buro, K., & Sheptycki, A. R. (2008). Relations among mindfulness, well-being, and sleep. *Personality and Individual Differences*, *45*, 773-777.

Hülsheger, U. R., Feinholdt, A., & Nübold, A. (2015). A low-dose mindfulness intervention and recovery from work: Effects on psychological detachment, sleep quality, and sleep duration. *Journal of Occupational and Organizational Psychology, 88,* 464-489.

Jain, S., Shapiro, S. L., Swanick, S., Roesch, S. C., Mills, P. J., Bell, I., & Schwartz, G. E. (2007). A randomized controlled trial of mindfulness meditation versus relaxation training: effects on distress, positive states of mind, rumination, and distraction. *Annals of behavioral medicine*, *33*, 11-21.

Kempke, S., Luyten, P., Mayes, L.C., Van Houdenhove, B., & Claes, S. (2015). Self-critical perfectionism predicts lower cortisol response to experimental stress in patients with chronic fatigue syndrome. *Health Psychology*, *35*, 3, 298-307.

Kroese, F. M., Evers, C., Adriaanse, M. A., & De Ridder, D.T. (2016). Bedtime procrastination: A self-regulation perspective on sleep insufficiency in the general population. *Journal of Health Psychology, 21,* 853-62.

Krystal, A.D. (2009). A compendium of placebo-controlled trials of the risks/benefits of pharmacological treatments for insomnia: The empirical basis for U.S. clinical practice. *Sleep Medicine Reviews*, *13*, 265–274.

Lin, M. K., Wu, A. W., Revicki, D. A. (2002). Incorporating quality of life measures in HIV clinical trials. *HIV Clinical Trials,* 3(3):202-18.

Lovibond, S.H., & Lovibond, P.F. (2004). *Manual for the Depression Anxiety Stress Scales, second edition.* Psychology Foundation, Sydney.

Lund H. G., Reider, B. D., Whiting, A. B., & Prichard, J. R. (2010). Sleep patterns and predictors of disturbed sleep in a large population of college students. *Journal of Adolescent Health, 46,* 124-132. doi: 10.1016/j.jadohealth.2009.06.016.

Lundh, L.-G. (2005). The role of acceptance and mindfulness in the treatment of insomnia. *Journal of Cognitive Psychotherapy*, *19*, 29–39.

Morin, C.M. (2006). Psychological and behavioral treatment of insomnia: Update of the recent evidence (1998-2004). *Sleep, 29,* 1398-1414.

Maslow, A. H. (1943). A theory of human motivation. *Psychological Review, 50,* 370–396.

Mouratidis, A., Vansteenkiste, M., Sideridis, G., & Lens, W. (2011). Vitality and interest-enjoyment as a function of class-to-class variation in need-supportive teaching and pupils' autonomous motivation. *Journal of Educational Psychology, 103,* 353-366.

Nicassio, P. M., Mendlowitz, D.R., Fussell, J.J., & Petras L. (1985). The phenomenology of the pre-sleep state—the development of the Pre-Sleep Arousal Scale. *Behaviour Research and Therapy, 23*, 263–71.

Nolen-Hoeksema, S., & Watkins, E. R. (2011). A Heuristic for developing transdiagnostic models of psychopathology: Explaining multifinality and divergent trajectories. *Perspectives on Psychological Science, 6*, 589-609.

Ong, J.C., Shapiro, S.L. & Manber, R. (2008). Combining mindfulness meditation with cognitive-behavior therapy for insomnia: A treatment-development study. *Behavior Therapy, 39,* 171-182.

Ong, J. C., Ulmer, C.S., & Manber, R. (2012). Improving sleep with mindfulness and acceptance: A metacognitive model of insomnia. *Behaviour Research and Therapy, 50,* 651-660.

Peltzer, K. (2012). Health-related quality of life and antiretroviral therapy in Kwazlu-Natal South Africa. *Social Behavior and Personality*, 40(2):267-282.

Phillips, K. D., Mock K. S., Bopp C. M., et al. (2006). Spiritual well-being, sleep disturbance, and mental and physical health status in HIV-infected individuals. *Issues in Mental Health Nursing*, 27:125–39.

Phillips, K,.D., Sowell, R.L., Boyd, M., et al. (2005). Sleep quality and health-related quality of life in HIV-infected African-American women of childbearing age. *Quality of Life Resarch,*14:959–70.

Poh, J.H., Chong, P.L.H., & Chee, M.W.L. (2016). Sleepless night, restless mind: Effects of sleep deprivation on mind wandering. *Journal of Experimental Psychology: General, 145,* 1312-1318.

Qaseem, A., Kansagara, D., Forceia, M.A. Cooke, M., & Denberg, T. (2016). Management of chronic insomnia disorder in adults: A clinical practice guideline from the American College of Physicians. *Annals of Internal Medicine*.

Quinlivian, E. B., Messer, L. C., Adimora, A. A., Roytburd, K., Bowditch, N., Parnell, H., Seay, J., Bell, L., & Pierce, J. K. (2013). Experiences with HIV testing, entry, and engagement in care by HIV-infected women of color, and the need for autonomy, competency and relatedness. *Aids Patient Care*, 27(7):408-415.

Riemann, D., Spiegelharder, K., Feige, B., Volderholzer, U., Berger, M., Perlis, M., Nissen, C. (2010). The hyperarousal model of insomnia: a reivew of the concept and its evidence. *Sleep Medicine Reviews*, *14(1),* 19-31.

Ryan, R. M., Bernstein, J. H., & Brown, K. W. (2010). Weekends, work, and well-being: Psychological need satisfactions and day of the week effects on mood, vitality, and physical symptoms. *Journal of Social and Clinical Psychology*, *29*, 95-122.

Ryan, R. M., & Deci, E. L. (2008). From ego depletion to vitality: Theory and findings concerning the facilitation of energy available to the self. *Social and Personality Psychology Compass*, 2/2, 702-717.

Ryan, R. M., & Deci, E. L. (2017). *Self-Determination Theory: Basic psychological needs in motivation, development, and wellness*. New York: Guilford.

Ryan, R. M., Deci, E. L., & Vansteenkiste, M. (2016). Autonomy and autonomy disturbances in self-development and psychopathology: Research on motivation, attachment, and clinical process. In D. Cicchetti (Ed.), *Developmental Psychopathology* (3 ed.).

Ryan, R. M., Lynch, M.F., Vansteenkiste, M., & Deci, E. (2011). Motivation and autonomy in counseling, psychotherapy, and behavior change: A look at theory and practice. *The counseling psychologist, 39, 2,* 193-260.

Savard, A., Joussemet, M., Pelletier, J. E., & Mageau, G. (2013). The benefits of autonomy support for adolescents with severe emotional and behavioral problems. Motivation and Emotion, *37*, 688-700.

Sheldon, K. M., & Filak, V. (2008). Manipulating autonomy, competence and relatedness support in a game- learning context: New evidence that all three needs matter. *British Journal of Social Psychology, 47,* 267- 283.

Sladek, M.R., & Doane, L.D. (2015). Daily diary reports of social connection, objective sleep, and the cortisol awakening response during adolescents' first year of college. *Journal of youth and adolescence*, *44*, 298-316.

Spielman, A.J., Saskin, P., & Thorpy, M.J. (1987). Treatment of chronic insomnia by restriction of time in bed. Sleep, 10, 45–55.

Staner, L. (2010). Comorbidity of insomnia and depression. *Sleep Medicine Reviews, 14,* 35-46.

Strine, T. W., & Chapman, D.P. (2005). Associations of frequent sleep insufficiency with health-related quality of life and health behaviors. *Sleep Medicine*, *6,* 23-27.

Taylor, D.J., & Roane, B.M. (2010). Treatment of insomnia in adults and children: A practice friendly review of research, 66 (11), 1137-1147.

Uchino, B. N., Cacioppo, J. T., & Kiecolt-Glaser, J. K. (1996). The relationship between social support and physiological processes: a review with emphasis on underlying mechanisms and implications for health. *Psychological Bulletin*, *119*, 488-531.

Unanue, W., Dittmar, H., Vignoles, V. L., & Vansteenkiste, M. (2014). Materialism and Well-being in the UK and Chile: Basic Need Satisfaction and Basic Need Frustration as Underlying Psychological Processes. *European Journal of Personality*, *28*, 569-585.

Van Asshe, J., Van der Kaap-Deeder, J., Audenaert, E., Schryver, M., & Vansteenkiste, M. Are the benefits of autnomy satisfaction and the costs of autonomy frustration dependent on individuals' autonomy strength? *Manuscript submitted for publication.*

Van der Kaap-Deeder, J., Vansteenkiste, M., Van Petegem, S., Raes, F., & Soenens, S. (2016). On the integration of need-related autobiographical memories among late adolescents and late adults: The role of depressive symptoms and self-congruence. *European Journal of Personality.*

Van der Kaap-Deeder, J., Audenaert, E., Vandevelde, S., Soenens, B., Van Mastrigt, S., Mabbe, E., & Vansteenkiste, M. (under revision). Choosing when choices are limited: The role of perceived afforded choice and autonomy in prisoners' well-being. *Manuscript under revision for Law and Human Behavior.*

Van der Kaap-Deeder, J., Vansteenkiste, M., Soenens, B., Verstuyf, J., Boone, L., & Smets, J. (2014). Fostering self-endorsed motivation to change in patients with an eating disorder: The role of perceived autonomy support and psychological need satisfaction. *International Journal of Eating Disorders, 47,* 585-600.

Vansteenkiste, M., & Ryan, R. M. (2013). On psychological growth and vulnerability: Basic psychological need satisfaction and need frustration as a unifying principle. *Journal of Psychotherapy Integration, 23,* 263-280.

Vansteenkiste, M., Simons, J., Lens, W., Sheldon, K. A., & Deci, E.L. (2004). Motivating learning, performance, and persistence: The synergistic effects of intrinsic goal contents and autonomy-supportive contexts. *Journal of Personality and Social Psychology, 87*, 246-260.

Verstuyf, J., Vansteenkiste, M., Soenens, B., Boone, L., & Mouratidis, A. (2013). Daily ups and downs in women's binge eating symptoms: The role of basic psychological needs, general self-control, and emotional eathing. Journal of Social and Clinical Psychology, 32, 335-361.

Weinstein, N., Brown, K. W., & Ryan, R.M. (2009). A multi-method examination of the effects of mindfulness on stress attribution, coping, and emotional well-being.

Weinstein, N., Khabbaz, F., & Legate, N. (2016). Enhancing need satisfaction to reduce psychological distress in Syrian refugees. *Journal of Consulting and Clinical Psychology* PMID 27018533. doi: 10.1037/ccp0000095

Weinstein, N., & Ryan, R. M. (2011). A self-determination theory approach to understanding stress incursion and responses. *Stress and Health*, *27*, 4-17.

Wicklow, A., & Espie, C. A. (2000). Intrusive thoughts and their relationship to actigraphic measurement of sleep: Towards a cognitive model of insomnia. *Behaviour Research and Therapy*, *38*, 679–694.

Yeung, N. C.Y., Ramirez, J., & Lu, Q. (2017). Perceived stress as a mediator between social constraints and sleep quality among Chinese American breast cancer survivors. *Support Care Cancer*, *25*, 2249-2257.

Nederlandstalige Samenvatting

Psychologische basisbehoeftes en slaap: Een multi-methode benadering van hun relatie en de onderliggende mechanismen in niet-klinische en klinische populaties

Inleiding

Iedereen die ooit een slechte nachtrust heeft gehad, kent de gevolgen van slechte slaap. Slecht slapen zorgt voor verminderde concentratie (Poh, Chong, & Chee, 2016), grotere vermoeidheid (Fuligni & Hardway, 2006) en een slechte stemming (Baum et al., 2014) de dag nadien. Op lange termijn kunnen chronische slaapproblemen zelfs het risico op ernstige gezondheidsproblemen zoals diabetes, hart- en vaatziekten, obesitas, en depressie verhogen (Strine & Chapman, 2015). In het licht van deze negatieve gevolgen is het belangrijk dat onderzoek betekenisvolle voorspellers van slaap weet te identificeren**.** Voorgaand onderzoek heeft aangetoond dat mensen die stress (Lund, Reider, Whiting & Prichard, 2010), eenzaamheid (Cacioppo et al., 2002) en financiële zorgen (Burgard & Ailshire, 2009) ervaren slechter slapen, terwijl mensen die mindful (Howell, Digdon, & Buro, 2010; Howell, Digdon, Buro, & Sheptycki, 2008) en dankbaar (Wood, et al., 2009) zijn beter slapen. Echter, voorgaand onderzoek naar de psychologische voorspellers van slaap werd niet altijd in een overkoepelend theoretisch kader gegrond.

De globale doelstelling van het huidige proefschrift was om het verband tussen de bevrediging en frustratie van de psychologische behoeftes aan autonomie (ervaren van psychologische vrijheid), competentie (ervaren van het effectiviteit en bekwaamheid) en verbondenheid (ervaren van warme en hechte relaties), zoals gedefineerd binnen de Zelf-Determinatie Theorie (ZDT; Ryan & Deci 2017), en diverse slaapuitkomsten te onderzoeken. Daarnaast onderzochten we de mogelijke verklarende rol van stress en negatieve slaapgerelateerde cognities in de behoefte-slaap associatie, alsook de wederkerige en causale verbanden tussen behoeftengerelateerde ervaringen en slaapuitkomsten. Tenslotte gingen we ook de rol van mindfulness in het bevorderen van behoeftebevrediging en daaropvolgende slaapuitkomsten na. Deze doelstellingen werden gerealiseerd via een reeks cross-sectionele, dagboek, en experimentele studies in zowel niet-klinische als klinische populaties en aan de hand van zowel subjectieve als objectieve metingen van slaap.

Doelstelling 1: De relatie tussen psychologische behoeftes en diverse slaapuitkomsten op zowel het tussen- als binnenpersoonsniveau.

De eerste doelstelling van dit proefschrift was om het verband tussen psychologische behoeftes en diverse slaapuitkomsten te onderzoeken in niet-klinische steekproeven. Hoofdstuk 2 omvat een cross-sectionele studie bij gezonde volwassen (Gemiddelde leeftijd = 31; N = 215) om na te gaan of de psychologische behoeftes een voorspeller zijn van verschillen in slaapuitkomsten *tussen personen*. Uit deze studie bleek dat lage psychologische behoeftebevrediging gedurende de afgelopen maand verband hield met slechtere slaapkwaliteit, een wat kortere slaapduur en meer dagelijks dysfunctioneren. Deze studie bood eerste bewijs voor een verband tussen behoeftengerelateerde ervaringen en diverse slaapuitkomsten.

In Hoofdstuk 3 werd een ander design gehanteerd: in plaats van een tussenpersoons- werd een binnenpersoonsdesign gebruikt, waarbij universiteitsstudenten (Gemiddelde leeftijd = 21.69; N = 121) gedurende verschillende weken werden gevolgd in een longitudinale studie. Specifiek rapporteerden universiteitsstudenten over hun behoeftengerelateerde ervaringen, slaap en dagelijks functioneren voor, tijdens en na een mogelijke stressvolle gebeurtenis, namelijk een examenperiode. De gemiddelde veranderingen in de uitkomsten gaven aan dat de ervaringen van de universiteitsstudenten systematisch covarieerden met de periode: zij rapporteerden minder behoeftebevrediging, slechtere slaap en dagelijks functioneren in de pre-examenperiode in vergelijking met de eigenlijke examenperiode en verbeterde behoeftebevrediging slaap en dagelijks functioneren van de examen tot de post-examenperiode. Daarnaast bleken toenames in behoeftefrustratie en dalingen in behoeftebevrediging samen te hangen met slechtere slaapkwaliteit en dagelijks functioneren tijdens de examenperiode, terwijl toenames in behoeftebevrediging en dalingen in behoeftebevrediging gepaard gingen met verbeteringen in slaap en dagelijks functioneren na de examenperiode. Echter, de relatie tussen behoeftengerelateerde ervaringen en slaapkwantiteit bleek minder robuust te zijn over de verschillende tijdstippen heen.

In Hoofdstuk 7 onderzochten we verder de co-variatie tussen psychologische behoeftes en slaapuitkomsten over de tijd heen, deze keer van dag tot dag. Twee dagboekstudies bij adolescenten

(Studie 6: Gemiddelde leeftijd = 15.86; N = 211; Studie 7: Gemiddelde leeftijd = 15.88; N = 51) werden uitgevoerd om te onderzoeken of dagelijkse variatie in behoeftebevrediging- en frustratie (binnenpersoons variatie) gerelateerd was aan dagelijkse variatie in vermoeidheid en slaapkwaliteit- en kwantiteit. Uit de resultaten van beide studies bleek dat dagelijkse behoeftefrustratie, veeleer dan behoeftebevrediging, een meer prominente rol speelde in het voorspellen van de slaapgerelateerde uitkomsten. Behoeftefrustratie voorspelde niet alleen meer dagelijkse vermoeidheid, maar bleek ook samen te hangen met slechtere dagelijkse slaapkwaliteit en kortere dagelijkse slaapduur. De bevindingen van de tweede studie die gerapporteerd wordt in Hoofdstuk 7 toonden ook aan dat de dagelijkse relatie tussen behoeftefrustratie en slaap niet beperkt was tot zelf-gerapporteerde slaapuitkomsten, maar ook teruggevonden werd indien gebruik werd gemaakt van objectieve indicatoren van slaapduur zoals gemeten door actigrafie.

Samengevat tonen deze cross-sectionele, longitudinale en dagboekstudies aan dat behoeftengerelateerde ervaringen gerelateerd zijn aan diverse slaapuitkomsten op zowel het binnen- als tussenpersoonsniveau bij niet-klinische steekproeven. Bovendien bleek uit de bevindingen dat de sterkte van het waargenomen verband afhankelijk was van de onderzochte uitkomst, waarbij de associatie met slaapkwaliteit en daggerelateerde uitkomsten het meest uitgesproken was. Kortom, deze bevindingen bieden initieel bewijs voor het feit dat dat mensen die minder behoeftebevrediging ervaren in hun leven slechtere slaapkwaliteit rapporteren en dat meer behoeftefrustratie van week tot week en van dag tot dag samenhangt met slechtere slaapkwaliteit.

Doelstelling 2: Onderzoeken of de geobserveerde bevindingen te veralgemenen zijn naar klinische groepen met slaapproblemen

De ZDT stelt dat de behoeftes aan autonomie, competentie, en verbondenheid universeel zijn. Dit wil zeggen dat de bevrediging van deze behoeftes het welbevinden bevordert, terwijl de frustratie van deze behoeftes tot nefaste volgen leidt bij alle personen, ongeacht hun achtergrond of klinische status. In lijn met deze universaliteitsclaim, was onze tweede doelstelling om te onderzoeken of de geobserveerde resultaten bij niet-klinische poulaties kunnen veralgemeend worden naar klinische groepen die te kampen hebben met fysieke dysfunctie en slaapproblemen.

In Hoofdstuk 4 werd, gebruik makend van een cross-sectioneel design, onderzocht of de psychologische behoefte-slaap associatie zou teruggevonden worden bij mensen met HIV (Gemiddelde leeftijd = 45.48; N = 101). Omdat levenskwaliteit een belangrijke uitkomst in HIV-onderzoek vormt (Lin, Wu & Revicki, 2002), werd in dit hoofdstuk ook gefocust op het verband tussen psychologische behoeftebevrediging en indicatoren van levenskwaliteit. Hierna hebben we onderzocht of de associatie tussen behoeftebevrediging en levenskwaliteit verklaard kon worden door slaapkwaliteit- en kwantiteit. Uit de resultaten bleek dat behoeftebevrediging een positief verband had met zowel fysieke als mentale gezondheid. Bovendien werden de verbanden met fysieke en mentale gezondheid respectievelijk volledig en gedeeltelijk verklaard door slaapkwaliteit. Slaapkwantiteit bleek daarentegen niet gerelateerd te zijn aan zowel behoeftebevrediging noch aan fysieke en mentale gezondheid.

In Hoofdstuk 5 werd een prospectieve correlationele studie opgezet om de rol van behoeftengerelateerde ervaringen in het voorspellen van subjectieve en objectieve slaapuitkomsten te onderzoeken in een groep individuen die klinisch onderzoek ondergingen omwille van aanhoudende klachten van onverklaarde chronische vermoeidheid (Gemiddelde leeftijd = 39.63; N = 160). De personen rapporteerden over hun ervaren behoeftebevrediging- en frustratie van de afgelopen week, waarna hun slaap objectief werd geregistreerd aan de hand van Polysomnografie (PSG) tijdens een verblijf in een slaaplaboratorium. Uit de resultaten bleek dat meer behoeftefrustratie in de afgelopen week, veeleer dan een gebrek aan behoeftebevrediging, indirect verband hield met slechtere slaapkwaliteit en kortere slaapduur tijdens de nacht doorgebracht in het slaaplabo via een ketting van verklarende mechanismen (verder toegelicht onder Doelstelling 3). Deze indirecte associaties deden zich voor in relatie met zowel subjectieve als objectieve kortere totale slaaptijd en subjectieve (maar niet objectieve) langere slaaplatentie (dwz., de tijd nodig om in slaap te vallen). Deze bevindingen toonden aan dat behoeftefrustratie niet enkel voorspellende kracht heeft voor zelfrapportages van slaapkwaliteit- en kwantiteit maar ook voor objectieve kwantitatieve slaapindicatoren, zoals gemeten met de gouden standaard in slaaponderzoek, met name de PSG.

In Hoofdstuk 6 (Gemiddelde leeftijd = 42.10; N = 90) werd een dagboekmethode gebruikt om te onderzoeken of het verband tussen behoeften en slaap ook zou teruggevonden worden van dag tot dag en dit bij patiënten met Chronisch Vermoeidheidssyndroom (CVS). Aangezien vermoeidheid de centrale klacht is van CVS patiënten en dat meerdere studies hebben aangetoond dat de psychologische behoeftes gerelateerd zijn aan subjectieve energie (bijv. Chen et al., 2015; Ryan & Deci, 2008) onderzochten we in deze studie eerst of dagelijkse variatie in behoeftebevrediging- en frustratie gerelateerd zou zijn aan dagelijkse variatie in subjectieve energie (vermoeidheid en vitaliteit). Vervolgens gingen we de rol van dagelijkse behoeftengerelateerde ervaringen in het voorspellen van dagelijkse slaapkwaliteit- en kwantiteit na. De resultaten van multilevel analyses toonden aan dat dagelijkse behoeftebevrediging samenhing met minder dagelijkse vermoeidheid en meer dagelijkse vitaliteit, terwijl het tegengestelde patroon werd waargenomen voor dagelijkse behoeftefrustratie. Dagelijkse behoeftefrustratie bleek ook verband te houden met slechtere dagelijkse slaapkwaliteit, maar bleek niet gerelateerd aan dagelijkse slaapkwantiteit. Dagelijkse behoeftebevrediging vertoonde geen samenhangen met slaapuitkomsten, noch met dagelijkse slaapkwaliteit, noch met dagelijkse slaap kwantiteit. Deze bevindingen tonen aan dat zowel dagelijkse behoeftebevrediging als dagelijkse behoeftefrustratie in het bijzonder voorspellend zijn voor de dagelijkse fluctuaties in energie bij CVS-patiënten, terwijl alleen dagelijkse behoeftefrustratie een rol speelt in de voorspelling van dagelijkse variatie in slaapkwaliteit bij deze patiëntengroep.

Samengevat blijkt dat de kritische rol van behoeftengerelateerde ervaringen in het voorspellen van diverse slaapuitkomsten grotendeels werd bevestigd in diverse klinische populaties. De bijdrage van de psychologische behoeftes aan energiegerelateerde uitkomsten (vermoeidheid en vitaliteit) bleek het meest robuust, terwijl de effecten op slaapkwaliteit en vooral slaapkwantiteit minder sterk waren en in sommige gevallen eerder indirect bleken te zijn. Dat wil zeggen dat een ketting van tussenliggende mechanismen opgenomen diende te worden om te begrijpen waarom de psychologische behoeftes een relatie vertonen met slaapkwaliteit- en kwantiteit. Deze tussenliggende mechanismen vormden de kern van Doelstelling 3.

Doelstelling 3: De rol van stress en negatieve slaapgerelateerde cognities als mogelijke verklarende processen.

De derde doelstelling van dit proefschift was om de mechanismen te identificeren die de geobserveerde relatie tussen behoeftengerelateerde ervaringen en slaap kunnen verklaren. In lijn met verschillende theorieën van chronische slaapstoornissen (bijv. Espie, Broomfield, MacMahon, Macphee & Taylor, 2006; Harvey, 2002; Riemann, et al., 2010) die stellen dat stress en dysfunctionele cognitieve processen een belangrijke rol spelen in het onderhouden van slaapproblemen, hebben wij in het huidige proefschift de potentiële verklarende rol van symptomen van stress, zoals spanning, opwinding en moeilijkheid om te ontspannen, evenals negatieve slaapgerelateerde gedachten (bijv. rumineren over de gevolgen van slecht slapen) in de relatie tussen psychologische behoeftes en slaapuitkomsten onderzocht.

In Hoofdstuk 3 exploreerden we de verklarende rol van stress in de korte termijn longitudinale studie waarin universiteitsstudenten bevraagd werden voor, tijdens en na een examenperiode. Een eerste reeks bevindingen die bewijs leveren voor de rol van stress omvat de systematische gemiddelde verschillen in stress, psychologische behoeftes en slaapgerelateerde uitkomsten in functie van de blootstelling aan de stressor (examenperiode). Uit de resultaten bleek dat er sprake was van significante veranderingen in stress over beide transities, waarbij de deelnemers meer stress rapporteerden tijdens de examenperiode, en een daling in stress rapporteerden na de examenperiode. Daarnaast bleekt stress een verklarende rol te spelen in de co-variatie tussen behoeftengerelateerde ervaringen en de slaap- en dag uitkomsten over de tijd. De resultaten van gecorreleerde veranderingsanalyses toonden aan dat de verschuivingen in behoeftegerelateerde ervaringen in de transitie van de voor- tot de examenperiode samenhingen met verschuivingen in slaapkwaliteit, die konden verklaard worden door verschuivingen in stress tijdens deze transitie. Op analoge wijze bleken verschuivingen in stress de samenhang tussen verschuivingen in behoeftegerelateerde ervaringen en verschuivingen in slaapkwaliteit in de examen – post-examen transitie te verklaren. Deze bevindingen boden evidentie voor de kritische verklarende rol van stress.

In Hoofdstuk 7 hebben we de verklarende rol van stress verder onderzocht, deze keer in de dagelijkse associatie tussen behoeftengerelateerde ervaringen en slaap. Meer specifiek onderzochten we in de tweede dagboekstudie bij adolescenten die gerapporteerd werd in hoofdstuk 7, of dagelijkse stress het verband tussen dagelijkse behoeftengerelateerde ervaringen en de slaapuitkomsten kon verklaren. De resultaten gaven aan dat dagelijkse behoeftefrustratie veeleer dan een gebrek aan behoeftebevrediging, voorspellend was voor dagelijkse stress. Dagelijkse stress op zijn beurt, droeg bij tot meer dagelijkse vermoeidheid, slechtere dagelijkse slaapkwaliteit en kortere objectieve slaapduur, waarvan de laatste gemeten was door actigrafie. Deze bevindingen leverden verder bewijs op voor de kritische verklarende rol van stress in de relatie tussen behoeftefrustratie en niet alleen subjectieve (slaapkwaliteit) maar ook objectieve (slaapduur) slaapuitkomsten.

In Hoofdstuk 5 werd, naast de verklarende rol van stress, ook de rol van negatieve slaapgerelateerde cognities (Fichten et al., 1998), in een steekproef van mensen met onverklaarde chronische vermoeidheid onderzocht. Meer specifiek rapporteerden deelnemers met onverklaarde chronische vermoeidheid over hun behoeftengerelateerde ervaringen en stress gedurende de afgelopen week tijdens een nachtverblijf in een slaaplaboratorium voor polysomnografie. Daarnaast werd de mate waarin ze negatieve slaapgerelateerde cognities ervoeren voor ze in slaap vielen evenals de kwaliteit en duur van hun slaap bij het ontwaken gemeten. In analogie met de bevindingen van de dagboekstudie bij adolescenten bleek ook in deze studie dat behoeftefrustratie veeleer dan gebrekkige behoeftebevrediging gerelateerd te zijn meer stress tijdens de voobije week, dat op zijn beurt hogere avondvermoeidheid voorspelde. Bovendien bleken symptomen van stress in combinatie met daaropvolgende negatieve slaapgerelateerde cognities tijdens het verblijf in het slaaplabo de relatie tussen hogere behoeftefrustratie en slechtere subjectieve slaapkwaliteit en kortere slaapduur tijdens het verblijf in het slaaplabo te verklaren.

Samengevat werden in het huidige proefschrift de eerste stappen gezet om een inzicht te krijgen in de mechanismen die het verband tussen behoeftengerelateerde ervaringen en slaapuitkomsten verklaren. Hoewel ook andere mechanismen relevant kunnen zijn leveren de huidige bevindingen evidentie op voor de verklarende rol van stress en negatieve slaapcognities in de relatie tussen psyhchologische behoeftes en slaapuitkomsten.

Doelstelling 4: Evidentie voor de wederkerige en causale verbanden tussen behoeftengerelateerde ervaringen en slaapuitkomsten.

Vele studies (bijv. Fuligni & Hardway, 2006; Galambos et al., 2009) hebben aangetoond dat slaap ook bijdraagt tot het psychologische functioneren van mensen de dag nadien. Onze vierde doelstelling was daarom om het wederkerige en causale verband te onderzoeken tussen slaap en psychologische behoeftes. Terwijl de focus in de vorige doelstellingen vooral op de rol van psychologische behoeftes in het voorspellen van slaap lag, erkennen we dat slaapkwaliteit- en kwantiteit ook kan bijdragen tot het psychologische functioneren van de mens. Binnen dit proefschrift werd deze wederkerigheid onderzocht in twee soorten studies, namelijk dagboekstudies (Hoofdstuk 6 en Hoofdstuk 7) en een experimentele studie (Hoofdstuk 8). Terwijl we in de dagboekstudies de wederkerige relatie tussen dagelijkse psychologische behoeftes en slaap hebben onderzocht, liet de experimentele studie toe om conclusies te trekken over het mogelijk causale verband tussen slaap en dagelijkse behoeftengerelateerde ervaringen.

In Hoofdstuk 6 onderzochten we of slaapkwaliteit- en kwantiteit bijdraagt tot dagelijkse variatie in behoeftengerelateerde ervaringen bij patiënten met Chronisch Vermoeidheidssyndroom (CVS). Uit de resultaten bleek dat slechtere slaapkwaliteit gerelateerd was met minder dagelijkse behoeftebevrediging en meer dagelijkse behoeftefrustratie. Echter, dagelijkse variatie in slaapkwantiteit bleek niet samen te hangen met behoeftengerelateerde ervaringen de dag nadien. In Hoofdstuk 7 onderzochten we het wederkerig verband tussen dagelijkse behoeftengerelateerde ervaringen en slaap aan de hand van twee dagboekstudies bij adolescenten. Resultaten uit de eerste dagboekstudie gaven aan dat zowel slechtere slaapkwaliteit als kortere slaapduur voorspellend was voor ervaren behoeftefrustratie de volgende dag. De tweede dagboekstudie repliceerde deze bevindingen gedeeltelijk door aan te tonen dat slechtere slaapkwaliteit een verband vertoonde met meer behoeftefrustratie de volgende dag, maar de dagelijkse variatie in objectieve slaapduur (gemeten door actigrafie) bleek niet gerelateerd te zijn met behoeftengerelateerde ervaringen de daaropvolgende dag. Samengenomen hebben deze studies bewijs opgeleverd voor de wederkerige relatie tussen slapen 's nachts, met name de subjectieve slaapkwaliteit, en dagelijkse behoeftengerelateerde ervaringen.

In Hoofdstuk 8 (Gemiddelde leeftijd = 32.81; N = 49) werden de effecten van een experimenteel geïnduceerd slaaptekort onderzocht. Specifiek dienden in deze experimentele studie gezonde volwassenen gedurende drie opeenvolgende dagen 5 uur per nacht slapen. Naast het effect op behoeftengerelateerde ervaringen, gingen we ook na of mindfulness onder deze omstandigheden zou aangetast worden omdat eerdere studies suggereren dat onvoldoende slaap ook een nadelig effect kan hebben op de aandachtscapaciteiten van de mens (bijv. Anderson & Horne, 2006; Poh, Chong, & Chee, 2016). Uit de bevindingen bleek dat, hoewel de deelnemers reeds toegenomen vermoeidheid rapporteerden na één dag van slaaptekort, het drie dagen duurde voordat zij verminderde behoeftebevrediging en mindfulness rapporteerden ten gevolgen van het slaaptekort.

Doelstelling 5: Het verband tussen mindfulness en slaapuitkomsten via behoeftebevrediging.

Vorig onderzoek heeft aangetoond dat mindfulness, geconceptualiseerd als “open and receptive present moment awareness” (Brown & Ryan, 2003), gerelateerd is aan betere slaap uitkomsten (bijv. Howell, Digdon, Buro, 2010; Howell, Digdon, Buro & Sheptycki, 2008). Echter, tot nu toe is weinig geweten over de mechanismen die deze relatie verklaren. Aangezien eerder onderzoek heeft aangetoond dat mindfulness samenhangt met hogere behoeftebevrediging (Brown & Ryan, 2003), was onze vijfde doelstelling om de mogelijke verklarende rol van behoeftebevrediging in de relatie tussen mindfulness en diverse slaapuitkomsten te onderzoeken. In Hoofdstuk 2 en Hoofdstuk 4 gingen we na of behoeftebevrediging de relatie tussen dispositionele mindfulness en slaap zou verklaren. Uit de cross-sectionele studie bij gezonde volwassen die gerapporteerd is in Hoofdstuk 2 bleek dat mindfulness gerelateerd was aan betere slaapkwaliteit en minder dagelijkse dysfunctie. Belangrijker nog, hogere behoeftebevrediging bleek de relatie tussen mindfulness en een betere slaapkwaliteit volledig te verklaren, terwijl de relatie met dagelijkse dysfunctie slechts gedeeltelijk verklaard werd door hogere behoeftebevrediging. In Hoofdstuk 4 werden deze bevindingen gerepliceerd. Meer specifiek bleek uit een cross-sectionele studie bij mensen met HIV opnieuw dat mindfulness gepaard ging met betere slaapkwaliteit. Bovendien kon de associatie tussen mindfulness en slaapkwaliteit volledig verklaard worden door hogere behoeftebevrediging. Deze studies geven aan dat mindfulness bevorderend is voor behoeftebevrediging wat op zijn beurt gerelateerd is met beter slaapkwaliteit.

Aangezien slaap ook een wederkerig invloed heeft op de psychologische behoeftes, is het ook mogelijk dat mindfulness helpt te verklaren waarom een experimenteel geïnduceerd slaaptekort behoeftengerelateerde ervaringen negatief beïnvloed. In Hoofdstuk 8 onderzochten we of experimenteel geïnduceerd slaaptekort toestandverschillen in mindfulness voorspelde bij gezonde volwassenen, die dan op hun beurt gerelateerd zijn aan behoeftengerelateerde ervaringen. Uit de resultaten bleek dat de deelnemers verminderde e mindfulness rapporteerden, wat op zijn beurt gerelateerd was aan verminderde behoeftebevrediging. Samengevat tonen deze initiële studies rond de rol van mindfulness in de behoefte-slaap associatie gaven aan dat mindfulness niet alleen kan dienen als voorspeller van behoeftebevrediging en daaropvolgende slaapuitkomsten maar dat verminderde mindfulness ook het gevolg kan zijn van slaaptekort.

Conclusie

Het huidige proefschrift heeft als eerste het verband tussen de bevrediging en frustratie van de psychologische basisbehoeften aan autonomie, competentie en verbondenheid, en diverse slaapuitkomsten systematisch onderzocht. In acht studies vonden we een relatie tussen psychologische behoeftengerelateerde ervaringen en diverse slaapuitkomsten (zelfgerapporteerde en objectieve) op zowel de tussen- als binnenpersoonniveau in niet-klinische en klinische populaties Daarnaast leverden de huidige bevindingen evidentie op voor de verklarende rol van stress en negatieve slaapgerelateerde cognities in de behoefte-slaap associatie. Bovendien werd aangetoond dat behoeftengerelateerde ervaringen niet enkel voorspellend waren voor, maar ook voorspeld werden door de kwaliteit en kwantiteit van slaap, wat suggereert dat beide wederkerig met elkaar verbonden zijn. Tenslotte wijzen de bevindingen er ook op dat mindfulness behoeftebevrediging bevordert en dat behoeftebevrediging op zijn beurt betere slaapuitkomsten voorspelt. Deze bevindingen impliceren dat zorgverstrekkers die mensen willen helpen om hun slaap te verbeteren zich kunnen richten op mindfulness en psychologische behoeftenbevrediging binnen de therapeutische behandeling.

Referenties

Anderson, C., & Horne, J. A. (2006). Sleepiness enhances distraction during a monotonous task. *Sleep, 29*, 573-576.

Baum, K.T., Desai, A., Field, J., Miller, L. E., Rausch, J., & Beebe, D.W. (2014). Sleep restriction worsens mood and emotion regulation in adolescents. *The Journal of Child Psychology and Psychiatry*, 55 (*2*), 180-190.

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology, 84*, 822–848. doi: 10.1037/0022-3514.84.4.822.

Burgard, S.A. & Ailshire, J. A. (2009). Putting work to bed: Stressful experiences on the job and sleep quality. *Journal of Health and Social Behaviour, 50*, 476-492.

Cacioppo, J. T., Hawkley, L. C., Bernston, G. C., Ernst, J. M., Gibbs, A. C., Stickgold, R., & Hobson, J. A. (2002). Do lonely days invade the nights? Potential social modulation of sleep efficiency. *Psychological Science*, *13*, 384-387.

Chen, B., Vansteenkiste, M., Beyers, W., Boone, L., Deci, E. L., Duriez, B. Lens, W., Matos, L., Mouratidis, A., Ryan, R. M., Sheldon, K. M., Soenens, B., Van Petegem, S., & Van der Kaap-Deeder, J., Verstuyf, J (2015). Basic psychological need satisfaction, need frustration, and need strength across four cultures. *Motivation and Emotion, 39*, 216-236.

Espie, C.A., Broomfield, N.M., MacMahon, K.M., Macphee, L.M., Taylor, L.M. (2006). The attention-intention-effort pathway in the development of psychophysiologic insomnia: a theoretical review. *Sleep Medicine Reviews*, 10 (*4*), 215-243.

Fichten, C.S., Libman, E., Creti, L., Amsel, R., Tagalakis, V., & Brender, W. (1998). Thoughts during awake times in older good and poorer sleepers – The self-statement test: 60+. *Cognitive Therapy and Research, 22(1)*, 1-20.

Fuligni, A. J., & Hardway, C. (2006). Daily variation in adolescents' sleep, activities, and psychological well-being. *Journal of Research on Adolescence, 16,* 353 – 377.

Galambos, N. L., Dalton, A. L., & Maggs, J. L. (2009). Losing sleep over it: Daily variation in sleep quantity and quality in Canadian students' first semester of university. *Journal of Research on Adolescence, 19*, 741-761.

Harvey, A.G. (2002). A cognitive model of insomnia. *Behavior Research and Therapy, 40*, 8, 869-893.

Howell, A. J., Digdon, N. L., & Buro, K. (2010). Mindfulness predicts sleep-related self-regulation and well-being. *Personality and Individual Differences, 48*, 419-424.

Howell, A. J., Digdon, N. L., Buro, K., & Sheptycki, A. R. (2008). Relations among mindfulness, well-being, and sleep. *Personality and Individual Differences, 45,* 773-777.

Lin, M. K., Wu, A. W., Revicki, D. A. (2002). Incorporating quality of life measures in HIV clinical trials. *HIV Clinical Trials*, 3(3):202-18.

Lund H. G., Reider, B. D., Whiting, A. B., & Prichard, J. R. (2010). Sleep patterns and predictors of disturbed sleep in a large population of college students. *Journal of Adolescent Health, 46,* 124-132. doi: 10.1016/j.jadohealth.2009.06.016.

Poh, J.H., Chong, P.L.H., & Chee, M.W.L. (2016). Sleepless night, restless mind: Effects of sleep deprivation on mind wandering. *Journal of Experimental Psychology: General, 145,* 1312-1318.

Riemann, D., Spiegelharder, K., Feige, B., Volderholzer, U., Berger, M., Perlis, M., Nissen, C. (2010). The hyperarousal model of insomnia: a reivew of the concept and its evidence. *Sleep Medicine Reviews, 14(1),* 19-31.

Ryan, R. M., & Deci, E. L. (2008). From ego depletion to vitality: Theory and findings concerning the facilitation of energy available to the self. *Social and Personality Psychology Compass,* 2/2, 702-717.

Ryan, R. M., & Deci, E. L. (2017). *Self-Determination Theory: Basic psychological needs in motivation, development, and wellness*. New York: Guilford.

Strine, T. W., & Chapman, D.P. (2005). Associations of frequent sleep insufficiency with health-related quality of life and health behaviors. *Sleep Medicine*, *6*, 23-27.

Wood, A. M., Joseph, S., Lloyd, J., & Atkins, S. (2009). Gratitude influences sleep through the mechanism of pre-sleep cognitions. *Journal of Psychosomatic Research*, *66*, 43–48.

Data Storage Fact Sheets

% Data Storage Fact Sheet (versie 7 maart 2014)

% Name/identifier study: PAID_2015 (PhD Dissertation: Chapter 2)

% Author: Rachel Campbell

% Date:26/02/2015

1. Contact details

==

1a. Main researcher

- name: Rachel Campbell

- address: Henri Dunantlaan 2, 9000 Ghent, Belgium

- e-mail: rachel.campbell@ugent.be

1b. Responsible Staff Member (ZAP)

- name: Maarten Vansteenkiste

- address: Henri Dunantlaan 2, 9000 Ghent, Belgium

- e-mail: maarten.vansteenkiste@ugent.be

If a response is not received when using the above contact details, please send an email to data-ppw@ugent.be or contact Data Management, Faculty of Psychology and Educational Sciences, Henri Dunantlaan 2, 9000 Ghent, Belgium.

2. Information about the datasets to which this sheet applies

===

* Reference of the publication in which the datasets are reported: Campbell, R., Vansteenkiste, M., Delesie, L., Mariman, A., Soenens, B., Tobback, E., Van der Kaap-Deeder & Vogelaers, D. (2015). Examining the role of psychological need satisfaction in sleep: A Self-Determination Theory perspective.Personality and Individual Differences, 77, 199-204. doi: http://dx.doi.org/10.1016/j.paid.2015.01.003

* Which datasets in that publication does this sheet apply to?: Main Study

3. Information about the files that have been stored

===

3a. Raw data

----

* Have the raw data been stored by the main researcher? [X] YES / [ ] NO

If NO, please justify:

* On which platform are the raw data stored?

- [X] researcher PC

- [X] research group file server

- [ ] other (specify): ...

* Who has direct access to the raw data (i.e., without intervention of another person)?

- [X] main researcher

- [X] responsible ZAP

- [X] all members of the research group

- [ ] all members of UGent

- [ ] other (specify): ...

3b. Other files

----

* Which other files have been stored?

- [X] file(s) describing the transition from raw data to reported results. Specify: SPSS syntax file for transition raw data in used variables and parcels

- [X] file(s) containing processed data. Specify: .dat file for mplus data

- [ ] file(s) containing analyses. Specify:

- [ ] files(s) containing information about informed consent. Specify: ...

- [ ] a file specifying legal and ethical provisions. Specify: ...

- [ ] file(s) that describe the content of the stored files and how this content should be interpreted. Specify: ...

- [ ] other files. Specify: ...

* On which platform are these other files stored?

- [X] individual PC

- [X] research group file server

- [ ] other: ...

* Who has direct access to these other files (i.e., without intervention of another person)?

- [X] main researcher

- [X] responsible ZAP

- [X] all members of the research group

- [ ] all members of UGent

- [ ] other (specify): ...

4. Reproduction

==

* Have the results been reproduced independently?: [ ] YES / [X] NO

* If yes, by whom (add if multiple):

- name:
- address:
- affiliation:
- e-mail:

% Data Storage Fact Sheet (versie 7 maart 2014)

% Name/identifier study: Exam_2017 (PhD Dissertation: Chapter 3)

% Author: Rachel Campbell

% Date:20/06/2017

1. Contact details

===

1a. Main researcher

- name: Rachel Campbell

- address: Henri Dunantlaan 2, 9000 Ghent, Belgium

- e-mail: rachel.campbell@ugent.be

1b. Responsible Staff Member (ZAP)

- name: Maarten Vansteenkiste

- address: Henri Dunantlaan 2, 9000 Ghent, Belgium

- e-mail: maarten.vansteenkiste@ugent.be

If a response is not received when using the above contact details, please send an email to data-ppw@ugent.be or contact Data Management, Faculty of Psychology and Educational Sciences, Henri Dunantlaan 2, 9000 Ghent, Belgium.

2. Information about the datasets to which this sheet applies

===

* Reference of the publication in which the datasets are reported:

Campbell, R., Vansteenkiste, M., Beyers, W., & Soenens, B. (submitted). University students' sleep during an exam period: The role of basic psychological needs and stress. *Manuscript submitted to Motivation and Emotion.*

* Which datasets in that publication does this sheet apply to?: Main Study

3. Information about the files that have been stored

===

3a. Raw data

----

* Have the raw data been stored by the main researcher? [X] YES / [ ] NO

If NO, please justify:

* On which platform are the raw data stored?

- [X] researcher PC
- [X] research group file server
- [ ] other (specify): ...

* Who has direct access to the raw data (i.e., without intervention of another person)?

- [X] main researcher
- [X] responsible ZAP

- [X] all members of the research group

- [ ] all members of UGent

- [ ] other (specify): ...

3b. Other files

----

* Which other files have been stored?

- [X] file(s) describing the transition from raw data to reported results. Specify: SPSS syntax file for transition raw data in used variables and parcels

- [] file(s) containing processed data. Specify:

- [ ] file(s) containing analyses. Specify:

- [ ] files(s) containing information about informed consent. Specify: ...

- [ ] a file specifying legal and ethical provisions. Specify: ...

- [ ] file(s) that describe the content of the stored files and how this content should be interpreted. Specify: ...

- [ ] other files. Specify: ...

* On which platform are these other files stored?

- [X] individual PC

- [X] research group file server

- [ ] other: ...

* Who has direct access to these other files (i.e., without intervention of another person)?

- [X] main researcher

- [X] responsible ZAP

- [X] all members of the research group

- [ ] all members of UGent

- [ ] other (specify): ...

4. Reproduction

===

* Have the results been reproduced independently?: [ ] YES / [X] NO

* If yes, by whom (add if multiple):

- name:
- address:
- affiliation:
- e-mail:

% Data Storage Fact Sheet (versie 7 maart 2014)

% Name/identifier study: JOHP_2016 (PhD Dissertation: Chapter 4)

% Author: Rachel Campbell

% Date: 20/06/2017

1. Contact details

===

1a. Main researcher

- name: Rachel Campbell

- address: Henri Dunantlaan 2, 9000 Ghent, Belgium

- e-mail: rachel.campbell@ugent.be

1b. Responsible Staff Member (ZAP)

- name: Maarten Vansteenkiste

- address: Henri Dunantlaan 2, 9000 Ghent, Belgium

- e-mail: maarten.vansteenkiste@ugent.be

If a response is not received when using the above contact details, please send an email to data-ppw@ugent.be or contact Data Management, Faculty of Psychology and Educational Sciences, Henri Dunantlaan 2, 9000 Ghent, Belgium.

2. Information about the datasets to which this sheet applies

==

* Reference of the publication in which the datasets are reported:

Campbell, R., Vansteenkiste, M., Delesie, L., Soenens, B., Tobback, E., Vogelaers, D., & Mariman, A. (2016). The role of basic psychological need satisfaction, sleep, and mindfulness in the health related quality of life of people living with HIV. *Journal of Health Psychology.*

* Which datasets in that publication does this sheet apply to?: Main Study

3. Information about the files that have been stored

==

3a. Raw data

----

* Have the raw data been stored by the main researcher? [X] YES / [ ] NO

If NO, please justify:

* On which platform are the raw data stored?

 - [X] researcher PC

 - [X] research group file server

 - [ ] other (specify): ...

* Who has direct access to the raw data (i.e., without intervention of another person)?

 - [X] main researcher

 - [X] responsible ZAP

 - [X] all members of the research group

 - [ ] all members of UGent

 - [ ] other (specify): ...

3b. Other files

----

* Which other files have been stored?

- [X] file(s) describing the transition from raw data to reported results. Specify: SPSS syntax file for transition raw data in used variables and parcels

- [] file(s) containing processed data. Specify:

- [ ] file(s) containing analyses. Specify:

- [ ] files(s) containing information about informed consent. Specify: ...

- [ ] a file specifying legal and ethical provisions. Specify: ...

- [ ] file(s) that describe the content of the stored files and how this content should be interpreted. Specify: ...

- [ ] other files. Specify: ...

* On which platform are these other files stored?

- [X] individual PC

- [X] research group file server

- [ ] other: ...

* Who has direct access to these other files (i.e., without intervention of another person)?

- [X] main researcher

- [X] responsible ZAP

- [X] all members of the research group

- [ ] all members of UGent

- [ ] other (specify): ...

4. Reproduction

==

* Have the results been reproduced independently?: [ ] YES / [X] NO

* If yes, by whom (add if multiple):

- name:
- address:
- affiliation:
- e-mail:

% Data Storage Fact Sheet (versie 7 maart 2014)

% Name/identifier study: Stress&Health_2017 (PhD Dissertation: Chapter 5)

% Author: Rachel Campbell

% Date: 20/06/2017

1. Contact details

===

1a. Main researcher

- name: Rachel Campbell

- address: Henri Dunantlaan 2, 9000 Ghent, Belgium

- e-mail: rachel.campbell@ugent.be

1b. Responsible Staff Member (ZAP)

- name: Maarten Vansteenkiste

- address: Henri Dunantlaan 2, 9000 Ghent, Belgium

- e-mail: maarten.vansteenkiste@ugent.be

If a response is not received when using the above contact details, please send an email to data-ppw@ugent.be or contact Data Management, Faculty of Psychology and Educational Sciences, Henri Dunantlaan 2, 9000 Ghent, Belgium.

2. Information about the datasets to which this sheet applies

==

* Reference of the publication in which the datasets are reported:

Campbell, R., Tobback, E., Delesie, L., Vogelaers, D., Mariman, A., & Vansteenkiste, M. (in press) Basic psychological need experiences, fatigue and sleep in individuals with unexplained chronic fatigue. *Stress and health.*

* Which datasets in that publication does this sheet apply to?: Main Study

3. Information about the files that have been stored

==

3a. Raw data

----

* Have the raw data been stored by the main researcher? [X] YES / [ ] NO

If NO, please justify:

* On which platform are the raw data stored?

  - [X] researcher PC

  - [X] research group file server

  - [ ] other (specify): ...

* Who has direct access to the raw data (i.e., without intervention of another person)?

  - [X] main researcher

  - [X] responsible ZAP

  - [X] all members of the research group

  - [ ] all members of UGent

  - [ ] other (specify): ...

3b. Other files

----

* Which other files have been stored?

- [X] file(s) describing the transition from raw data to reported results. Specify: SPSS syntax file for transition of raw data into used variables

- [] file(s) containing processed data. Specify:

- [ ] file(s) containing analyses. Specify:

- [ ] files(s) containing information about informed consent. Specify: ...

- [ ] a file specifying legal and ethical provisions. Specify: ...

- [ ] file(s) that describe the content of the stored files and how this content should be interpreted. Specify: ...

- [ ] other files. Specify: ...

* On which platform are these other files stored?

- [X] individual PC

- [X] research group file server

- [ ] other: ...

* Who has direct access to these other files (i.e., without intervention of another person)?

- [X] main researcher

- [X] responsible ZAP

- [X] all members of the research group

- [ ] all members of UGent

- [ ] other (specify): ...

4. Reproduction

===

* Have the results been reproduced independently?: [ ] YES / [X] NO

* If yes, by whom (add if multiple):

- name:
- address:
- affiliation:
- e-mail:

% Data Storage Fact Sheet (versie 7 maart 2014)

% Name/identifier study: CFS_2017 (PhD Dissertation: Chapter 6)

% Author: Rachel Campbell

% Date: 20/06/2017

1. Contact details

===

1a. Main researcher

- name: Rachel Campbell

- address: Henri Dunantlaan 2, 9000 Ghent, Belgium

- e-mail: rachel.campbell@ugent.be

1b. Responsible Staff Member (ZAP)

- name: Maarten Vansteenkiste

- address: Henri Dunantlaan 2, 9000 Ghent, Belgium

- e-mail: maarten.vansteenkiste@ugent.be

If a response is not received when using the above contact details, please send an email to data-ppw@ugent.be or contact Data Management, Faculty of Psychology and Educational Sciences, Henri Dunantlaan 2, 9000 Ghent, Belgium.

2. Information about the datasets to which this sheet applies

==

* Reference of the publication in which the datasets are reported:

Campbell, R., Vansteenkiste, M., Delesie, L., Tobback, E., Mariman A., & Vogelaers, D. (under revision). Day-to-day fluctuations in subjective energy and sleep in chronic fatigue syndrome: The role of psychological need experiences. *Manuscript under revision for Health Psychology.*

* Which datasets in that publication does this sheet apply to?: Main Study

3. Information about the files that have been stored

==

3a. Raw data

----

* Have the raw data been stored by the main researcher? [X] YES / [ ] NO

If NO, please justify:

* On which platform are the raw data stored?

  - [X] researcher PC

  - [X] research group file server

  - [ ] other (specify): ...

* Who has direct access to the raw data (i.e., without intervention of another person)?

  - [X] main researcher

  - [X] responsible ZAP

  - [X] all members of the research group

  - [ ] all members of UGent

  - [ ] other (specify): ...

3b. Other files

----

* Which other files have been stored?

- [X] file(s) describing the transition from raw data to reported results. Specify: SPSS syntax file for transition of raw data into used variables

- [] file(s) containing processed data. Specify:

- [ ] file(s) containing analyses. Specify:

- [ ] files(s) containing information about informed consent. Specify: ...

- [ ] a file specifying legal and ethical provisions. Specify: ...

- [ ] file(s) that describe the content of the stored files and how this content should be interpreted. Specify: ...

- [ ] other files. Specify: ...

* On which platform are these other files stored?

- [X] individual PC

- [X] research group file server

- [ ] other: ...

* Who has direct access to these other files (i.e., without intervention of another person)?

- [X] main researcher

- [X] responsible ZAP

- [X] all members of the research group

- [ ] all members of UGent

- [ ] other (specify): ...

4. Reproduction

==

* Have the results been reproduced independently?: [ ] YES / [X] NO

* If yes, by whom (add if multiple):

- name:
- address:
- affiliation:
- e-mail:

% Data Storage Fact Sheet (versie 7 maart 2014)

% Name/identifier study: DiaryAdol_2017 (PhD Dissertation: Chapter 7)

% Author: Rachel Campbell

% Date: 20/06/2017

1. Contact details

===

1a. Main researcher

- name: Rachel Campbell

- address: Henri Dunantlaan 2, 9000 Ghent, Belgium

- e-mail: rachel.campbell@ugent.be

1b. Responsible Staff Member (ZAP)

- name: Maarten Vansteenkiste

- address: Henri Dunantlaan 2, 9000 Ghent, Belgium

- e-mail: maarten.vansteenkiste@ugent.be

If a response is not received when using the above contact details, please send an email to data-ppw@ugent.be or contact Data Management, Faculty of Psychology and Educational Sciences, Henri Dunantlaan 2, 9000 Ghent, Belgium.

2. Information about the datasets to which this sheet applies

===

* Reference of the publication in which the datasets are reported:

Campbell R., Vansteenkiste, M., Soenens, B., Vandenkerckhove, B., & Mouratidis, A. (submitted). Examining daily variation in adolescent sleep: The role of psychological need experiences. *Manuscript submitted to Journal of Personality and Social Psychology.*

* Which datasets in that publication does this sheet apply to?: Study 1 and Study 2

3. Information about the files that have been stored

===

3a. Raw data

----

* Have the raw data been stored by the main researcher? [X] YES / [ ] NO

If NO, please justify:

* On which platform are the raw data stored?

- [X] researcher PC

- [X] research group file server

- [ ] other (specify): ...

* Who has direct access to the raw data (i.e., without intervention of another person)?

- [X] main researcher

- [X] responsible ZAP

- [X] all members of the research group

- [ ] all members of UGent

- [ ] other (specify): ...

3b. Other files

----

* Which other files have been stored?

- [X] file(s) describing the transition from raw data to reported results. Specify: SPSS syntax file for transition of raw data into used variables

- [] file(s) containing processed data. Specify:

- [ ] file(s) containing analyses. Specify:

- [ ] files(s) containing information about informed consent. Specify: ...

- [ ] a file specifying legal and ethical provisions. Specify: ...

- [ ] file(s) that describe the content of the stored files and how this content should be interpreted. Specify: ...

- [ ] other files. Specify: ...

* On which platform are these other files stored?

- [X] individual PC

- [X] research group file server

- [ ] other: ...

* Who has direct access to these other files (i.e., without intervention of another person)?

- [X] main researcher

- [X] responsible ZAP

- [X] all members of the research group

- [ ] all members of UGent

- [ ] other (specify): ...

4. Reproduction

==

* Have the results been reproduced independently?: [ ] YES / [X] NO

* If yes, by whom (add if multiple):

- name:
- address:
- affiliation:
- e-mail:

% Data Storage Fact Sheet (versie 7 maart 2014)

% Name/identifier study: SleepDep_2017 (PhD Dissertation: Chapter 8)

% Author: Rachel Campbell

% Date: 20/06/2017

1. Contact details

===

1a. Main researcher

- name: Rachel Campbell

- address: Henri Dunantlaan 2, 9000 Ghent, Belgium

- e-mail: rachel.campbell@ugent.be

1b. Responsible Staff Member (ZAP)

- name: Maarten Vansteenkiste

- address: Henri Dunantlaan 2, 9000 Ghent, Belgium

- e-mail: maarten.vansteenkiste@ugent.be

If a response is not received when using the above contact details, please send an email to data-ppw@ugent.be or contact Data Management, Faculty of Psychology and Educational Sciences, Henri Dunantlaan 2, 9000 Ghent, Belgium.

2. Information about the datasets to which this sheet applies

==

* Reference of the publication in which the datasets are reported:

Campbell, R., Soenens, B., Weinstein, N., & Vansteenkiste, M. (2017). Impact of partial sleep deprivation on psychological functioning: Effects on mindfulness and basic psychological need satisfaction.

* Which datasets in that publication does this sheet apply to?: Study 1 and Study 2

3. Information about the files that have been stored

===

3a. Raw data

----

* Have the raw data been stored by the main researcher? [X] YES / [ ] NO

If NO, please justify:

* On which platform are the raw data stored?

- [X] researcher PC
- [X] research group file server
- [ ] other (specify): ...

* Who has direct access to the raw data (i.e., without intervention of another person)?

- [X] main researcher
- [X] responsible ZAP
- [X] all members of the research group
- [ ] all members of UGent
- [ ] other (specify): ...

3b. Other files

----

* Which other files have been stored?

- [X] file(s) describing the transition from raw data to reported results. Specify: SPSS syntax file for transition of raw data into used variables

- [] file(s) containing processed data. Specify:

- [ ] file(s) containing analyses. Specify:

- [ ] files(s) containing information about informed consent. Specify: ...

- [ ] a file specifying legal and ethical provisions. Specify: ...

- [ ] file(s) that describe the content of the stored files and how this content should be interpreted. Specify: ...

- [ ] other files. Specify: ...

* On which platform are these other files stored?

- [X] individual PC

- [X] research group file server

- [ ] other: ...

* Who has direct access to these other files (i.e., without intervention of another person)?

- [X] main researcher

- [X] responsible ZAP

- [X] all members of the research group

- [ ] all members of UGent

- [ ] other (specify): ...

4. Reproduction

==

* Have the results been reproduced independently?: [ ] YES / [X] NO

* If yes, by whom (add if multiple):

- name:
- address:
- affiliation:
- e-mail:

Correlations

Table 1

Correlations between the needs for autonomy, competence, and relatedness, and the outcomes: Chapter 2 (Cross-sectional study adults)

	Autonomy	Competence	Relatedness
Autonomy	-		
Competence	.66**	-	
Relatedness	.55**	.56**	-
Mindfulness	.36**	.33**	.33**
Financial strain	-.28**	-.32**	-.25**
Poor Sleep Quality			
Negative reasons	-.26**	-.35**	-.23**
Sleep disturbances	-.17*	-.06	-.06
Sleep latency	-.15*	-.16*	-.20**
Subjective poor sleep quality	-.24**	-.33**	-.19**
Insomnia	-.36**	-.37**	-.32**
Sleep quantity			
Sleep duration	.11	.04	.08
Habitual sleep efficiency	.10	.17*	.12
Daytime dysfunction			
Vitality	.51**	.45**	.29**
Lassitude	-.46**	-.42**	-.28**
Fatigue severity	-.37**	-.33**	-.25**
Daytime dysfunction	-.27**	-.31**	-.15*
Mean	3.43	4.10	3.67
SD	.76	.70	.76

Note. $^*p<.05$, $^{**}p < .01$

Table 2

Correlations between the satisfaction and frustration of the needs for autonomy, competence, and relatedness, and the outcomes: Chapter 3 (Short-term longitudinal study emerging adults)

	Autonomy satisfaction	Competence satisfaction	Relatedness satisfaction	Autonomy frustration	Competence frustration	Relatedness frustration
Autonomy satisfaction	-					
Competence satisfaction	.45**/.62**/.55**	-				
Relatedness satisfaction	.46**/.43**/.50**	.42**/.40**/.45**	-			
Autonomy frustration	-.47**/-.51**/-.61**	-.32**/-.40**-.37**	-.21*/-.30**/-.27*	-		
Competence frustration	-.51**/-.54**/-.43**	-.66**/-.82**/-.63**	-.36**/ -.48**/-.48**	.54**/.47**/.50**	-	
Relatedness frustration	-.43**/-.41**/-.37**	-.41**/-.45**/-.38**	-.57**/-.62**/-.70**	.41**/.47**/.42**	.60**/.64**/.71**	-
Stress	-.30**/-49**/-.25*	-.37**/-.53**/-.46**	-.26**/ -.26**/-.36**	.50**/.57**/.39**	.56**/.61**/.53**	.37**/.55**/.53**
Sleep quantity	.16 /.09 /.04	.25*/.13.06	.21*/ -.03/ .09	-.19. /-.12/-.13	-.26**/-.13/-.16	-.46**/-.04/-.27*
Poor sleep quality	-.17 / -.27**/ -.25*	-.37**/-.30*-.44***	-.25**/ -.15/ -.20	.22*/.33**/.26*	.41**/.29**/.46**	.35**/.24*.28**
Daytime Dysfunction	-.54**/ -.64**/-.48**	-.48**/.54**/-.33**	-.49**/-.38**/ -.32**	.52**/.62**/.53**	.55**/.53**/.44**	.45**/.52**/.38**
Mean	3.41 /3.02 / 3.77	3.41 /3.20 / 3.77	4.00 / 3.86/ 4.08	3.02 / 3.24/ 2.20	2.34 / 2.61/ 1.84	1.59 / 1.67/ 1.61
SD	.70 / .66/ .59	.66 / .82/ .66	.62 / .58/ .60	.79 / .77/ .82	.95 / 1.01/ .84	.69 / .69/ .72

Note. *p<.05,**p < .01.
Pre exam period / Exam period / Post exam period

Table 3

Correlations between the needs for autonomy, competence, and relatedness and the outcomes: Chapter 4 (Cross-sectional people living with HIV)

	Autonomy	Competence	Relatedness
Autonomy	-		
Competence	.73**	-	
Relatedness	.69**	.65**	-
Mindfulness	.61**	.52**	.52**
Sleep Quality			
Poor sleep quality	-.38**	-.38**	-.38**
Sleep latency	-.23*	-.23*	-.13
Sleep disturbances	-.22*	-.30**	-.24*
Use of sleep medication	-.44**	-.39**	-.40**
Sleep Quantity			
Sleep duration	.13	.11	.24*
Habitual sleep efficiency	.03	.09	.25*
HRQOL			
Global physical health	.31**	.24*	.33**
Global mental health	.52**	.46**	.42**
Mean	3.48	3.70	3.98
SD	.82	.74	.72

Note. *p<.05,**p < .01

Table 4

Correlations between the needs for autonomy, competence, and relatedness and the outcomes: Chapter 5 (Prospective study unexplained chronic fatigue)

	Autonomy satisfaction	Competence satisfaction	Relatedness satisfaction	Autonomy frustration	Competence frustration	Relatedness frustration
Autonomy satisfaction	-					
Competence satisfaction	.66**	-				
Relatedness satisfaction	.49**	.31**	-			
Autonomy frustration	-.53**	-.42**	-.34**	-		
Competence frustration	-.56**	.68**	-.36**	.52**	-	
Relatedness frustration	-.37**	-.39**	-.60**	.36**	.51**	-
Stress	-.33**	-.38**	-.33**	.49**	.45**	.40**
Fatigue	-.17*	-.23**	-.05	.15	.23**	.12
Negative Sleep-related cognitions	-.23**	-.26**	-.04	.23**	.17*	.20*
Subjective sleep quality	.12	.21*	.03	-.12	-.17*	-.09
Subjective total sleep time	.18*	.12	.01	.02	.09	-.03
Subjective sleep latency	.03	.10	.03	-.11	-.01	.07
Subjective WASO	-.04	-.09	-.03	.00	.02	-.07
Objective total sleep time	.01	.06	-.08	.06	.06	.06
Objective sleep latency	-.20*	-.18*	.02	-.04	.12	-.02
Objective WSO	.02	-.02	.08	-.06	-.09	.07
Mean	3.40	3.35	4.17	2.87	2.45	1.69
SD	.82	.80	.75	.96	.97	.78

Note. *p<.05,**p < .01

Table 5

Correlations between the needs for autonomy, competence, and relatedness and the outcomes: Chapter 6 (Diary Study CFS patients)

	Autonomy satisfaction	Competence satisfaction	Relatedness satisfaction	Autonomy frustration	Competence frustration	Relatedness frustration
Day-level measures						
Autonomy satisfaction	-					
Competence satisfaction	.70**	-				
Relatedness satisfaction	.58**	.46**	-			
Autonomy frustration	-.65**	-.41**	-.43**	-		
Competence frustration	-.53**	.81**	-.44**	.49**	-	
Relatedness frustration	-.40**	-.38**	-.71**	.40**	.56**	-
Subjective energy						
Fatigue	-.26**	-.31**	-.05	.34**	.29**	-.06
Vitality	.42**	.51**	.19*	-.27**	-.37**	-.05
Sleep outcomes						
Sleep quality	.22*	.35**	.02	-.15	-.26**	.03
Sleep quantity	.06	.08	.06	-.04	-.07	-.12
Mean	3.31	3.25	4.16	2.50	2.15	1.59
SD	.58	.53	.64	.73	.75	.57

Note. *p<.05,**p < .01

Table 6

Within-person correlations between the needs for autonomy, competence, and relatedness and the outcomes: Chapter 7 (Diary study 1 adolescents)

	Autonomy Satistfaction	Competence satisfaction	Relatedness satisfaction	Autonomy frustration	Competence frustration	Relatedness frustration
Autonomy satisfaction	-					
Competence satisfaction	.50**	-				
Relatedness satisfaction	.44**	.34**	-			
Autonomy frustration	-.25**	-.04	-.10**	-		
Competence frustration	-.19**	-.11**	-.14**	.51**	-	
Relatedness frustration	-.21**	-.10**	-.23**	.41**	.39**	-
Fatigue	-.23**	-.14**	-.11**	.36**	.37**	.30**
Subjective sleep quality	.14**	.09**	.11**	-.13**	-.16**	-.18**
Subjective sleep quantity	.10**	.06**	.02	-.12**	-.11**	-.07**
Mean	3.24	2.99	3.84	2.19	1.84	1.88
SD	.97	.88	.96	.95	.79	.89

Note. *p<.05,**p < .01

Table 7

Within-person correlations between the needs for autonomy, competence, and relatedness and the outcomes: Chapter 7 (Diary study 2 adolescents)

	Autonomy satisfaction	Competence satisfaction	Relatedness satisfaction	Autonomy frustration	Competence frustration	Relatedness frustration
Autonomy satisfaction	-					
Competence satisfaction	.53**	-				
Relatedness satisfaction	.48**	.49**	-			
Autonomy frustration	-.41**	-.33**	-.43**	-		
Competence frustration	-.39**	-.60**	-.43**	.48**	-	
Relatedness frustration	-.32**	-.37**	-.58**	.40**	.58**	-
Fatigue	-.23**	-.28**	-.25**	.45**	.42**	.28**
Stress	-.14**	-.28**	-.20**	.34**	.53**	.44**
Subjective sleep quality	.06	.14**	.19**	-.20**	-.21**	-.27**
Objective sleep quantity	.07	.01	.03	-.13**	-.19**	-.08
Mean	3.19	3.41	3.84	2.39	2.32	1.58
SD	1.00	.85	.85	1.01	1.03	.83

Note. **p*<.05,***p* < .01